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THE BACCHANTE.

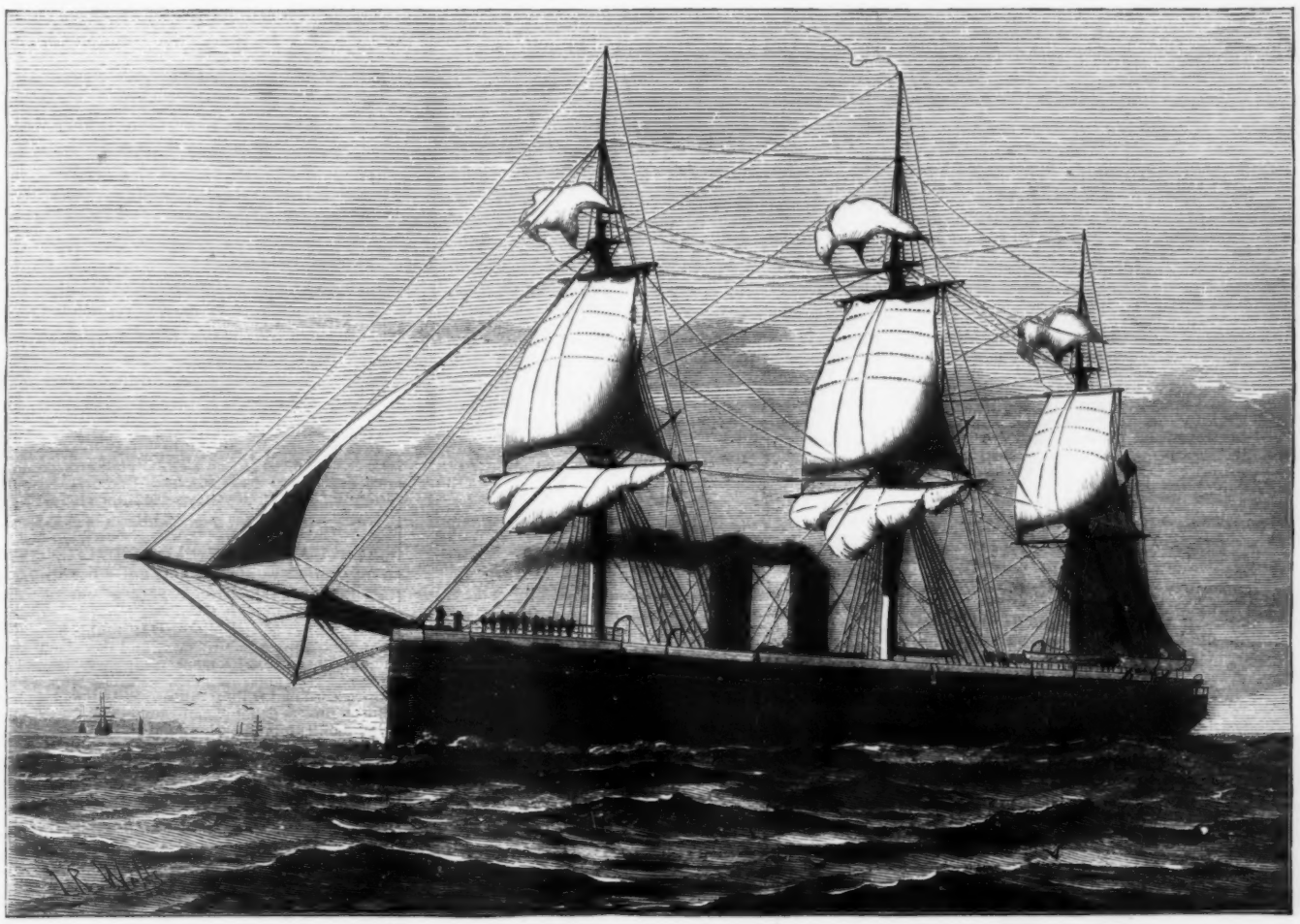
THE unarmored screw corvette Bacchante, 16, Captain Lord Charles T. M. D. Scott, which has been selected to take the royal midshipmen, Prince Albert Victor and George Frederick of Wales, on a cruise round the world, lately made a measured-mile trial of her machinery in Stokes Bay. In 1877 the corvette made a six hours' run, but on that occasion she was "flying light," having neither guns nor stores on board and being in a very incomplete state. The trial was purely a contractors' trial, and was undertaken for the satisfaction of the Portsmouth Steam Reserve previously to the machinery being taken over by the Admiralty. Her draught on the occasion was 15 feet 4 inches forward, and 21 feet 6 inches aft; or, in other words, her trim was such that while the stern was immersed to within 1 foot 4 inches of her estimated draught, her bows were 5 feet 4 inches higher than her load-line. The results, therefore, did not afford, nor were they intended to afford, any idea as to the performances of the ship, while affording at the same time a very fair test as to the efficiency of the machinery. On this occasion, however, having received on board her powder and shot and been thoroughly completed for sea, the Bacchante made a speed trial of her engines, her draught on the occasion being 21 feet forward and 23 feet 4 inches aft.

The trial was carried out under the superintendence of Captain Wells, of the Steam Reserve, Mr. C. Icely being in charge of the machinery. Mr. Bannister, of the Admiralty, and Mr. Durston, of the Factory Department, were also in attendance, the contractors' firm being represented by Mr. Phillips. The Bacchante is 280 feet between her perpendiculars, 45 feet in extreme breadth, 15 feet 7 inches deep in the hold, and has a displacement of 3,932 tons. It was originally intended that she should be in every respect a sister ship of the Boadicea, but after the drawings had been received at Portsmouth it was determined to introduce important modifications. The inner thickness of wood-sheathing was ordered to be removed and the frame line filled out to a distance equal to the inner thickness of the wood removed, while the outer thickness of sheathing was ordered to be increased from 3 inches to 6 inches at the water-line. Zinc has been substituted for the usual copper sheathing, with unplanished edges, so that as the water gains access to the iron skin a galvanic battery or couple is set up. An oxide is thus formed on the surface, which, on being washed off, carries with it the accumulating weeds and preserves the bottom clean. Instead of the knee-head and overhanging figure-head of the Boadicea, the Bacchante is built with a straight stem, the bowsprit being arranged to run in over the forecastle and enable the corvette to be used as a ram against armed merchantmen and wooden ships. In all other respects she is the exact counterpart of the older ship. She carries two 90 cwt. guns on the upper deck and twelve 90 cwt. and a couple of 44-pounder rifled guns on the main deck.

The engines, which were manufactured by Messrs. J. and G. Rennie, Blackfriars Road, London, have developed the greatest power through a single screw shaft of any compound engines yet tried, while the several diagrams taken from the cylinders show that the engines give considerable uniformity of power in the high and low pressure cylinders at all speeds. They are of the horizontal return-action type, and consist of three cylinders, the high-pressure cylinder being 73 inches and the two low-pressures 92 inches in diameter, with a stroke of 4 feet. The cranks in connection with the low-pressure cylinders are on the same plane, but in contrast as regards throw, the center crank being at right angles with them. The boilers supply steam at an initial pressure of 70 lb., but the engines are adapted to work steadily at very low as well as at very high powers, as well as at various powers between the extreme limits. It was ascertained at the previous steam trials under way that when the indicated power is as low as 75 and 143 horses, the initial pressure in the high-pressure cylinder varies from 5¾ lb. to 6¼ lb. below the atmosphere; while with the *maximum* power of 5,432, the initial pressure was 67 lb. above the atmosphere. The ship got under way shortly after 5 o'clock in the morning, a slight breeze blowing across her bow and quarter relatively to her course, the sea being smooth throughout the runs. About 8 o'clock, the furnaces having been worked up to the requisite liveliness, and the steam in the boilers having attained a pressure of 70 lb., the Bacchante was placed upon the mile, four runs being made at full power, and two runs each at two-thirds and one-third power. The following very satisfactory results were obtained:

	Full Power.	Two-thirds Power.	One-third Power.
Steam in boilers	70 lb.	69·5 lb.	67·5 lb.
Vacuum, forward	26·62 in.	26·87 in.	26·85 in.
Vacuum, aft	26·62 in.	26·25 in.	27·0 in.
Revolutions per minute	76·01	66·56	54·13
Mean pressure, high	30·425 lb.	29·10 lb.	20·30 lb.
Mean pressure, low	12·512 lb.	7·825 lb.	4·65 lb.
Total indicated power	5,412·28	3,633·43	1,926·60 lb.
Speed of vessel, knots	15·091	13·633	11·093

Nothing could be more satisfactory than the manner in which the machinery worked throughout, the horse power developed being 200 in excess of the contract. The speed also fully justified the expectations of the designers of the ship. The ship was tested in turning at full and half power with the following results: Under full power the starboard circle was made in 5 min. 46 sec. (diameter 687 yards), and the port circle in 7 min. 23 sec. (diameter 732 yards); and with half power the starboard circle was completed in 5 min. 34 sec. (diameter 530 yards), and the port circle in 5 min. 41 sec. (diameter 538 yards). Twelve men were required at the wheel. It only requires to be added that the engines were stopped in 9 sec.; being stopped, they were started astern in 11 sec., and from going astern they were started ahead in 9 sec., being under perfect control.



H. M. S. BACCHANTE.

A LARGE STEAMER.

ONE of the largest steamers ever built was recently launched from the yard of Messrs. John Elder & Co., Fairfield, Govan. She was named the Orient, and is intended for the new Orient Line of steamships trading between London and Australia, and making the passage in from 38 to 40 days, without requiring to stop to take in an additional supply of coal. The new vessel is a splendid specimen of the latest developments in the science of naval architecture. She is 460 ft. long, 46 ft. 6 in. broad, 37 ft. 8 in. deep, with a displacement of 9,500 tons at the load draught, and she is to be fitted with a set of three-cylinder engines of 5,400 indicated and 1,000 nominal horse power. We believe this vessel is the largest merchant steamer afloat, save the Great Eastern, and is another instance of the tendency to follow Brunel's lead.

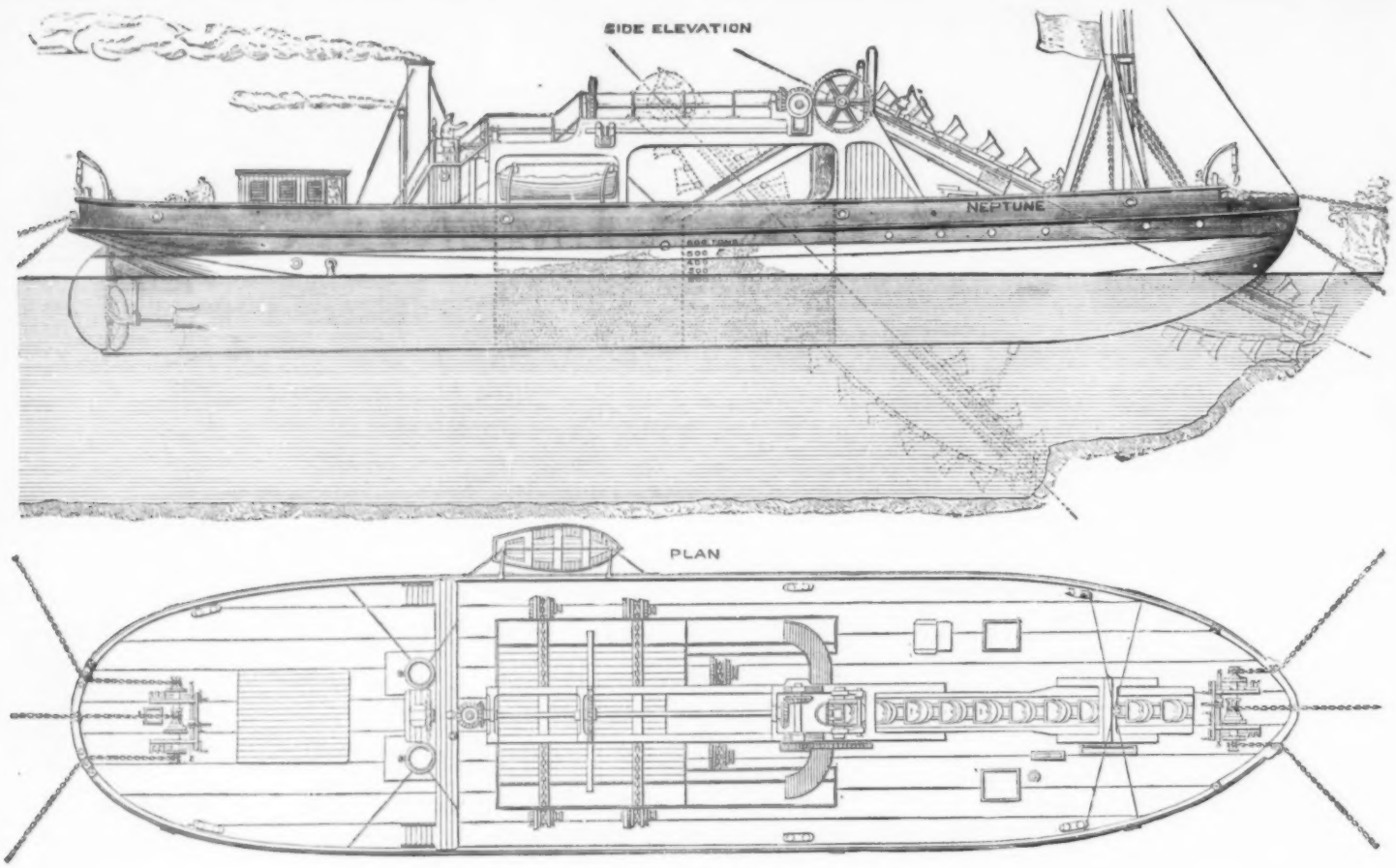


FIG. 1.—NEW STEAM DREDGER.

NEW STEAM DREDGER.

WE illustrate a twin screw hopper dredger, the Neptune, which has been constructed by Messrs. W. Simons & Co., of Renfrew, for the Newhaven Harbor of the London, Brighton, and South Coast Railway Company. Messrs. Simons, as our readers are aware, have been constructing hopper dredgers for a good many years; and the vessel now illustrated combines the best results of their experience, together with a very considerable amount of that of Mr. W. Stroudley and Mr. Banister, locomotive superintendent and engineer respectively of the above railway. A list of this vessel's performances shows that the amount of material lifted and discharged is greater than anything we remember to have met with before at the same cost. The principal dimensions of the vessel and her machinery are as follows: length, 145 feet; breadth, 32 feet; depth, 13½ feet; the hopper hold contains about 550 tons of soil. The engines, two independent sets, are on the compound system, and there are two cylindrical boilers; one engine with one boiler is capable of driving the dredging gear, and when steaming, each engine works its own screw propeller. The dredging girder and its chain of buckets can be traversed forward in advance of the bow, which is so formed as to enable it, when required, to cut the vessel's own floatation through shoals, bars, and sand banks. The buckets are capable of raising 300 tons per hour, and of loading the hopper cavity in less than two hours, and when at constant work, the consumption is about one ton of coal per load of 500 tons raised and deposited. The entire crew consists of ten hands. The cost of working during week ending the 22d March, 1879, is as follows, viz.:

Wages of crew	£23 18 4
Coal consumed (15½ tons) and cost of loading	14 4 10
	£38 3 2
Mud raised and discharged	6,750 tons.
Number of trips	13
Mud per trip	519 tons.
Cost per trip	£2 18s 8d.
Cost per ton of mud raised and discharged	1·35d.

The Neptune steamed round from the Clyde to Newhaven, Sussex, in four days, and by it the dredging operations are conducted with one crew, without barges, punts, or tugs.

Respecting a larger but nearly similar vessel of same type, the Willunga, the Government engineer's annual report for 1878 states: "The Willunga had nearly removed the outer bar at Port Adelaide, having cut a channel to a width of 300 ft. by 3,600 ft. in length, giving a depth of 20 ft. at low water, and had raised during last year 263,385 tons from the bar and deposited the same at sea."

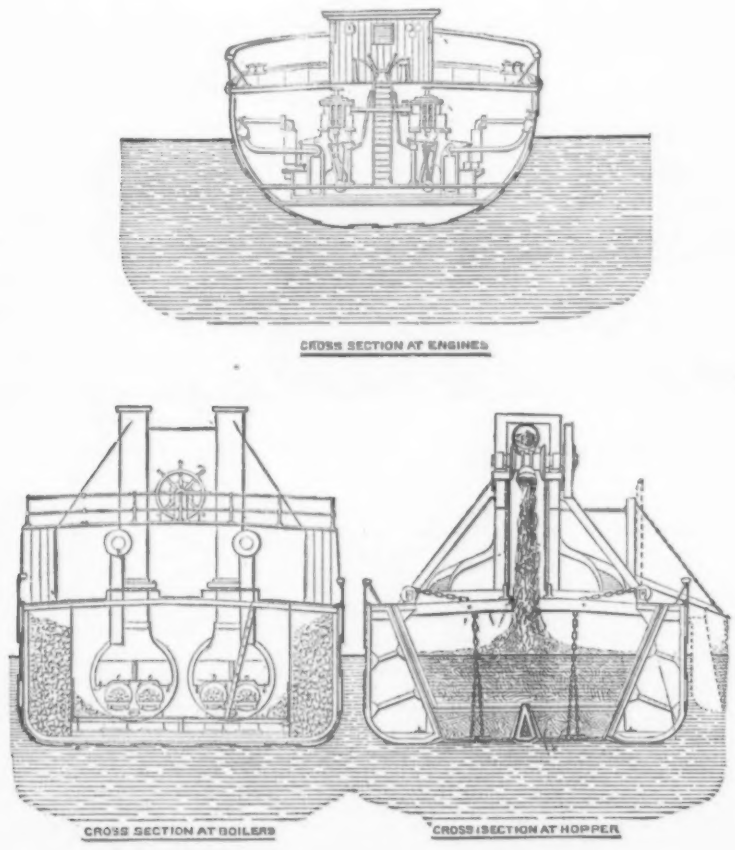


FIG. 2.—NEW STEAM DREDGER.

[Continued from SUPPLEMENT, No. 189.]

AMERICAN ENGINEERING.—IV.*

HYDRAULICS—WATER AS APPLIED TO COMMERCIAL INDUSTRIES AND DOMESTIC PURPOSES WITHIN THE UNITED STATES—AMERICAN CANALS.

AMONG the earlier immigrants to this country there were many mechanics and artisans, and the small streams in the neighborhood of settlements were soon utilized for the purposes of grist and saw mills, to which later were added tanneries, card and fulling mills. With the organization of the States under one general government, the necessities of means of communication and of exchange of commodities called attention to the improvements in inland navigation adopted in other countries, and rivers began to be improved by the construction of dams, with supplementary canals around dangerous falls, as early as 1792. From these small beginnings other canals were projected and carried out through the Northern and Middle States, so that at the inception of railroads, say in 1835, there were in the United States over 3,500 miles of navigable canals and many miles of slack water navigation.

With the introduction and spread of railways, the construction of canals almost entirely ceased, and many already in operation were discontinued, but many of the important ones have been improved and their carrying facilities increased, and at this time the tonnage of the canals, consisting mostly of grain, coal, lumber, and heavy materials, is an important factor in our internal commerce. The Erie Canal, built by the State of New York to connect the waters of Lake Erie with those of the Hudson River, completed in 1825, did much to develop the resources of the State, and to establish the city of New York as the largest port of the United States.

Its enlargement was commenced about 1840, and completed in 1862. Its present depth of water is 7 feet, and maximum capacity of boats, 240 tons. Its cost to 1876 was $49,000,000, and the tonnage for the year 1877 was 857,305,563 tons, carried one mile, while that of the New York Central Railroad, during same year, was 1,619,948,685 tons one mile. The length of the main Erie Canal is 352 miles, and with connections and feeders, 907 miles; movement on all those canals, about 5,000,000 tons. In Pennsylvania the canals are used largely for the transport of coal. The Lehigh Coal and Navigation Company transported by their canals, in 1876, about 1,000,000 tons; the Delaware and Hudson Canal, 1,300,000 tons; the Schuylkill and Susquehanna, about the same; and the Pennsylvania canals, about 900,000 tons. The Chesapeake and Ohio Canal carries on a

* American Engineering as illustrated by the American Society of Civil Engineers at the Paris Exhibition of 1878. Compiled by George S. Morrison, Edward P. North, and John Bogart, Committee, Transactions of the Amer. Soc. of Civil Engineering.

large coal trade between the Cumberland coal region and Washington and Alexandria.

The Morris Canal, in New Jersey, connecting the Delaware River with New York harbor, with feeders extending into the coal region, still continues to do a considerable coal trade. On this canal the experiment of inclined planes was first tried, and they are still in successful use. Along the eastern coast, by the connection of the sloop canal of Albemarle Sound with Chesapeake Bay, Chesapeake Bay with Delaware Bay, and Delaware Bay with the Raritan River, there is inland navigation from Albemarle Sound to New York city.

In Illinois, the Illinois and Michigan Canal, from Chicago to La Salle, opens the navigation between the great lakes and the Mississippi River, and carried in 1873 eight million bushels of grain and fifty million feet of lumber, besides large freights in shingles and laths. There is a short canal at Sault St. Mary's connecting the navigation of Lake Superior with that of the other great lakes.

WATER POWERS.

As said above, at a very early date the small streams in the neighborhood of settlements were utilized for saw and grist mills and the like, but it was not till the war of 1812–15, when an embargo was laid upon our commerce, that capital began to be used largely in industrial works, first by individuals or small firms developing the old water powers for the driving of cotton and woolen mills, thence still further utilizing the smaller streams, like the Charles, the Blackstone, and the Passaic. But with the increase in demand for goods, and profit in their manufacture, the necessity for large mills was recognized, and as large capital was not in single hands, corporations of combined capital were organized to develop large water powers for more extensive industries. It was found, in 1821, that the old canal of the Locks and Canals on the Merrimac could be made readily available, and the whole water of the Merrimac, with a fall of 30 feet, could be made use of, and this power, it was supposed, would supply an almost indefinite demand. The Locks and Canal Company became the owners of nearly all the land in the neighborhood of the canal within the limits of the present city of Lowell, and sold land with mill powers, a mill power being equivalent to 25 cubic feet per second on a 30 foot fall. At the present time they are running up to about 200 mill powers.

With the success of Lowell, water companies on the same basis were organized throughout the different States, water power and land belonging to these corporations, and the mills to others. Manchester and Lawrence were built on the Merrimac; Lewiston, on the Androscoggin; Biddeford, on the Saco; Bellows Falls, Turner's Falls, Holyoke and Windsor Locks, on the Connecticut; Ansonia, on the Naugatuck; Derby, on the Housatonic; Cohoes, on the Mohawk; Rochester, on the Genesee; Paterson and Dundee, on the Passaic; Trenton, on the Delaware; Manayunk, on the Schuylkill, and many others.

At the first the science of hydraulics was but little understood, and capital not abundant; the dams were mostly of timber, and the canals of but little capacity. Now most of the dams are substantial structures, and canals of such section that the velocity of the flow is often less than 2 feet per second.

AMERICAN WATER WHEELS.

The earlier water wheels were almost invariably overshot, pitch-back, or breast wheels. Many were of large dimensions, and well constructed, with cast iron shafts. The percentage of useful effect was sometimes as high as 80 per cent., but the average was considerably below 70 per cent.

But with the introduction of the Fourneyron wheel in France, the attention of engineers here was called to it, and Mr. Edward Morris constructed and put into operation one near Philadelphia, which indicated 75 per cent. of useful effect. In 1844, Mr. U. A. Boyden constructed one for the Appleton Company, at Lowell, which gave 78 per cent., and in 1846, two for the same company, which gave 88 per cent., and many other wheels with equally good results.

The quantity of water was invariably determined by the flow over a weir, and the mechanical effect by a Prony dynamometer, and as the compensation of Mr. Boyden was dependent on the percentage of useful effect obtained, it became very important that the formula for the flow over weirs should be rigorously determined. And as the formula thus far was derived from discharges of water and breadth of weir much less than were necessary for comparison with the discharge of large turbines, Mr. James B. Francis, at the expense of the Locks and Canals Company of Lowell, undertook a long course of trials, which have been published under the title of "Lowell Hydraulic Experiments," and as the most satisfactory form of formula Mr. Francis adopted that recommended by Mr. Boyden, in which the correction of length of weir for end contractions is a factor of the depth on the weir, and in taking the heights of water above the weir he adopted Mr. Boyden's hook gauge as the most accurate. The formulæ obtained by Mr. Francis are now the standard throughout this country, and are adopted wherever a wheel is to be tested.

The success of Mr. Boyden's wheels were due to their design and to the accuracy of their mechanical details and finish, the later wheels having bronze buckets to the wheels and guides. They were as expensive as steam engines of the same power, but they still endure after years of work.

Wheels of this form were more adapted to mills than the old breast or over-shot wheels, occupying a great deal less space, running at a more suitable speed, and more easily regulated, and when it was demonstrated that the percentage of effect was greater, the manufacture of reacting wheels spread throughout the country. Jonval wheels were built at Philadelphia, Paterson, Cohoes, and various forms were experimented on elsewhere to secure high percentage of useful effect, with cheapness of construction. At the first it was not possible to exceed that already obtained by Mr. Boyden, but it was thought possible that wheels of cheap construction and with a very fair percentage of effect could be made. This has been done; the forms now most generally adopted are wheels with a central and downward discharge; and makers, before issuing circulars to the public, either test their wheels at their works or have them tested by weir discharge and Prony dynamometer, and their guarantee of power is based generally on a standard of 80 per cent. of useful effect.

HYDRAULIC ENGINEERING IN CALIFORNIA.

Water for manufacturing purposes is estimated by cubic feet of discharge multiplied by feet of fall. In California, where the water is used for washing earths and ores, water is sold by the inch, that being usually the quantity which escapes through an orifice one inch square with the water six inches deep above the top of the orifice; as measured an inch of water is considered equal to 2 1-3 cubic feet per minute. The mining ditches of the State (1871) carry at least 100,000 inches, or about 2,500,000,000 gallons in 24 hours. This water is carried in open canals, in wooden frames and iron pipes. The latter are used now invariably in crossing deep ravines, and the necessities of the positions have led to the adoption of heroic engineering precedents in regard to the thickness of metal, coupled with diameter of pipe. Thus the Swartsville pipe, 16 inches diameter, under 180 feet pressure, of No. 18 sheet iron, was laid in 1861, not painted inside but painted on the out. San Juan, 30 inches diameter, Nos. 12 and 14 iron, 55 feet head, coated inside and out, laid in 1861. Chinese camp, Nos. 12, 14, 16, and 18 iron, maximum head 800 feet, was laid in 1868. The pipes are double riveted on the longitudinal seams, put together like stove pipes and riveted, and coated with coal tar.

Most of the water thus distributed is used, as is said, "to hydraulic," that is, to wash banks of auriferous earth by throwing a stream of water upon them through a hose and pipe. Hydraulic claims are usually in hills. The water is brought to the bottom of the hill by an iron pipe or by a hose. The hose is of heavy duck, and from 4 to 10 inches diameter, sometimes surrounded by iron rings 2 inches wide and 3 inches apart, connected by 4 ropes. It is important to preserve as great a head as possible, with flexibility of hose. The nozzles are like those of fire engine hose, sometimes as large as 8 inches diameter, with a discharge of 300 to 800 inches of water. The miners usually turn the stream upon the banks near the bottom until a large mass of earth tumbles down. They then wash all this away into the sluice, and then cut the bank again at the bottom. The water usually costs 10 cents per inch per day, and dirt in this way has been in some places excavated at a profit when it contained one cent's worth of gold in a cubic foot. The same hydraulic process has been used for excavation merely.

Besides water for washing earths, canals are used in California for irrigation, and in 1876 there were 915 irrigating ditches supplying water to 90,344 acres.

WATER SUPPLY OF AMERICAN CITIES.

Few of even the medium-sized cities of the United States are without some system of water supply and distribution. Philadelphia was first in the inception of such works, which was effected by the construction of a dam across the Schuylkill, with breast wheels and pumps raising water into a reservoir and then distributing it through the city. The breast wheels have given way to more efficient reactors, and the supply has been supplemented by steam pumping engines, both on the Schuylkill and on the Delaware.

New York is supplied by gravitation, bringing the water from the Croton through some 38 miles of brick aqueduct and some iron conduit. The iron conduit or pipe lines across Harlem and Manhattan Valley have been increased in capacity. A large receiving reservoir of 1,000,000,000 gallons capacity, and two large catch basins on the Croton river, have been constructed since the completion of the works, together with two pumping engines, of 10,000,000 gallons per 24 hours capacity, for the supply of the highest parts of the city. The daily supply is now about 90,000,000 gallons.

Boston has also a gravitation supply from Lake Cochituate, but has lately constructed an entirely new aqueduct, taking all the upper waters of the Sudbury river. By the annexation of Charlestown, the pumping works of Mystic pond have been added. The total daily supply is now about 50,000,000 gallons.

The supply of Washington is also by gravitation from the Potomac, and is the largest in quantity in proportion to the number of its inhabitants.

But, in general, most of the cities are supplied by steam pumping engines, of which the exhibit of St. Louis is a very fine type, and, together with those of Messrs. Leavitt and Worthington, represent our best practice.

THE SANDUSKY STAND PIPE.

Usually with all city waterworks there are reservoirs. In some cases the pumping is directly into the main, without reservoirs. In Sandusky the engineer, Mr. J. D. Cooke, has introduced, as an economical construction, under the conditions of position, a very large stand pipe, serving, in a measure, as a reservoir, with a small central pipe which will be useful in putting an extra head on the mains in case of fires. The large pipe, 25 feet inner diameter, 180 feet high; the central pipe 8 feet diameter, 230 feet high. The large pipe is of steel plate, having a reliable tensile strength of 70,000 lb. The plates build 4 feet per course, each course being composed of 6 plates, 1st and 2d course $\frac{7}{8}$ in. thick, three rows of $1\frac{1}{16}$ in. steel rivets, then reducing by each two courses the thickness of the plates by $\frac{1}{16}$ in.; the 43d and 45th course, inclusive, is $\frac{5}{16}$ in. plates, $\frac{1}{2}$ in. rivets, double. The rivets were changed from triple to double rows at 24th course. The top is finished with galvanized iron cornice; the whole thoroughly painted, inside and out. Influent and effluent pipes pass into and through the shell of large pipe near the bottom. Either pipe can be used independently of the other; valves so arranged that the engineer can change to either pipe without leaving the engine house.

AMERICAN PUMPING ENGINES.

The types of pumping engines used at the different works are extremely varied. The drawings sent to the exposition are very favorable specimens of American practice. The pumping engines of Mr. Leavitt are compound engines, with the steam cylinders inclined to each other, and at their bases are close to each other as possible. The connections are with opposite ends of the beam, and the channels between the cylinders are short as possible. The fly-wheel connection is with one end of the beam, and the pump connection with the other. This type of engine, of which there are three in operation—one at Lynn and two at Lawrence—both in their tests by experts and every day running, have given the best percentage of effect of any in the country.

The Worthington engine is the legitimate growth from the donkey engine which was first introduced for the feed of boilers by Messrs. Worthington & Baker. In its present form, as a pumping engine for water supply to towns, it is a compound horizontal engine, with two sets of high and low pressure cylinders, and its distinctive character is, that the steam valves of one set of cylinders are moved by the piston rods of the other. There are, probably, more of these engines than of any other one type; they are well adapted to a very fair percentage of duty, and they are economical, in first cost including foundations, and repair in working. They are of medium size, the largest in operation having a capacity of 8,000,000 gallons per 24 hours.

The St. Louis engines are of the largest capacity of any in this country. Engines Nos. 1 and 2, high service, are simple beam engines, with the pumps beneath the steam cylinders and directly connected; the crank connection is with the opposite extremity of the beam. The pump is of a type first introduced by Mr. Wm. Wright at the Brooklyn Water Works. The pump cylinder being inclosed in an annular cylinder, acting as a supplementary pipe to the pump, and affording more ample passage for the water than could be secured through the pump bucket alone. Engine No. 3, high service, is a coupled compound beam engine, with the two steam cylinders set close to each other and attached to the same side of the beam. The pump and crank connections are with the opposite ends of the beams. At the low service the water is pumped from the river into subsiding basins, and thence, by the high service, into the mains and reservoir. Engines Nos. 1 and 2, low service, are Bull engines, that can be run coupled. No. 3 is a beam engine, with two plunger pumps, one beneath the steam cylinder and directly connected therewith. On the piston-rod there is a connection with the extremity of a beam, at whose other extremity there is another pump and a fly-wheel connection. This pumping engine has two distinct condensers, the first in connection with a regular air pump on the main piston-rod, which is supplied by injection from the clear water main of the city, and the condensed water is used entirely for the supply of the boilers, at from 140° to 150°. The other is a siphon condenser supplied from the pump chamber with river water, and the condensation is effected by means of a sprinkler. All this condensed water is returned to the river.

Of late, all the pumping engines of a capacity of 5,000,000 gallons per 24 hours, and above, have been fitted with compound engines. The St. Louis engine, No. 3, may represent the type of Milwaukee, Chicago, and Lowell. In the Yonkers engine Mr. Wright has placed the cylinders vertically and at opposite ends of the beam. There are a great many Bull and Cornish engines used for the supply of towns and drainage of mines, and the English pump of Drury has been introduced into California. The pumps of the Holly system are inclined cylinders, with directly connected pumps beneath and a connection above with a crank on a fly-wheel shaft, usually with four cylinders, two at each end of the shaft, and arrangements to work either simply or compound.

The forms of boilers are, perhaps, more varied than that of the engines. The most usual types are the *horizontal tubular*, fired underneath and returning through the tubes; the *drop flue*, horizontal with large flues to a back connection, thence out at the bottom and back to the chimney; and the *Cornish*.

PUMPING ENGINE AT LAWRENCE, MASS.

Designed by E. D. LEAVITT, Jr., C. E.

The engines are two, with a single fly-wheel between them. The two steam cylinders, both steam jacketed, are placed beneath the main center of a working beam, and inclined outwardly at the top to connect with opposite ends of the beam, reducing thereby the length of the steam passage between the cylinders, equalizing the stroke, and economizing space, with a strong and compact frame.

The cylinder valves are all gridiron valves, with large area of opening and small movement. The steam valves to the high-pressure cylinders are operated by cams controlled by governors, one to each engine. When running coupled, the cam of one engine is set and the other controlled by its governor.

Air-pump double-acting; feed-pump connected with air-pump rod. The pumps are of the Thames Ditton variety, bucket and plunger, but with a supplementary delivery pipe. There are seven double-beat valves for suction, and four in the supplementary pipe, and the bucket valve for the delivery. Attached to the lower valve chamber there is a small spherical chamber with an air-cock at the top, by which air may be introduced into the pump, which is found, at particular stages of water in the well, to contribute to ease in the working of the pump.

TABLE OF DIMENSIONS.

Diameter of high-pressure cylinders	18 inches.
" low " "	38 "
" high " " rods	$3\frac{1}{2}$ "
" low " " "	4 "
" air-pumps	15 "
" pump-barrel	$26\frac{1}{8}$ "
" " plunger	$18\frac{1}{2}$ "
" " " rod	$4\frac{1}{2}$ "
" bottom and supplementary valves outside lower seat	$15\frac{3}{4}$ "
" bottom and supplementary valves inside upper seat	$12\frac{1}{2}$ "
" bucket-valves outside lower seat	22 "
" " inside " "	15 "
" air-chamber	54 "
" fly-wheel	30 feet.
Length of stroke of steam and water pistons	8 "
" " air-pump	28 inches.
Distances between end centers of beam	$16\frac{1}{2}$ feet.
Lead on steam-valves	0
" high-pressure exhaust valves	$\frac{1}{8}$ inch.
" low-pressure inlet	$\frac{1}{16}$ "
" " " exhaust bottom	$3\frac{5}{16}$ "
" " " " top	$4\frac{3}{16}$ "

All measured on stroke of pistons.

Cushion on high-pressure top exhaust	$14\frac{1}{4}$ "
" " bottom "	$14\frac{3}{4}$ "
" low-pressure top "	$4\frac{1}{2}$ "
" " bottom "	$8\frac{1}{4}$ "

Volume of clearance and port space:

High pressure top	0·0256 of cylinder capacity.
" bottom	0·0231 " "
Low-pressure top	0·0154 " "
" bottom	0·0182 " "
Connecting pipe between cylinders	0·0992 H. P. " "
Weight of fly-wheel	35,900 lb.
" walking-beam, including pins and counter-balance	25,700 "
" high pressure piston and connections	2,575 "
" low " " "	4,175 "
" air-pump " "	1,800 "
" pump, plunger bucket	7,200 "
" main connections, beam to crank	3,800 "

PUMPING ENGINES OF ST. LOUIS WATER WORKS.

The first type is No. 1, low service engine. There are two engines precisely of this type. They are Cornish engines, of the kind introduced by Capt. Bull. The principal dimensions are as follows: Diameter of steam cylinder 56", stroke 144", speed $8\frac{1}{2}$ to 9 strokes per minute, air-pump

28" diameter, stroke 72". Main pump 56"×144", being the same as the steam cylinder. The pump is a plunger pump. The lift of water is from 15 to 50 feet, according to the stage of water in the Mississippi river, from which the supply is taken.

The capacity of each pump is 17,000,000 United States gallons in 24 hours. These engines were built by the Knapp Fort Pitt Foundry Co. of Pittsburg, Pennsylvania, in 1870. The pump valves and seats are of composition, "Government standard," viz.: copper, 85 per cent., tin, 10 per cent., spelter, 5 per cent. The valves are "Cornish equilibrium," arranged in two tiers of twelve valves each. Diameter of lower valve seat 17", of upper valve seat 15", lift of valve 1¼". These two engines were erected by the parties above mentioned, in accordance with a proposal made by them on February 15, 1868, to construct the two engines for $89,800. Steam for these engines is supplied by two internally fired fixed boilers, two for each engine. They have each 650 square feet heating surface, and 27½ square feet of grate surface. The boilers are 7 feet diameter and 30 feet long, the flues 30" diameter, the full length.

The second type of engine is Engine No. 3, low service, a crank and fly-wheel engine with Wright's valve gear, built by General B. Allen & Co. of St. Louis, 1874. The contract was awarded in accordance with a proposal made on November 11, 1872, to construct the engine for $118,500. The principal dimensions of the engine are as follows: Steam cylinder 60"×84" without steam jacket, air pump (single acting) 26"×84". Two main pumps 50"×84" each. The pump valves are of leather and hinged, placed in the central chamber in two tiers. The capacity was intended to be 1,000,000 United States gallons per hour. The action of the valve gear is excellent. The lift of water is that already stated for Nos. 1 and 2 engine, viz., from 15 to 50 feet.

The third type of engine is Nos. 1 and 2, high service engines, which are alike. The engines are very similar to No. 3 Ridgewood engine at the Brooklyn Water Works, described in Mr. Kirkwood's book, "The Brooklyn Water Works." The engine is a crank and fly wheel engine with a beam. The principal dimensions are, steam cylinder 85"×120" (jacketed). Air pump 36"×60", double acting. The main pump is directly under the steam cylinder, and worked by an extension of the piston rod. The pump is a bucket and plunger pump of the kind known as "Thames Ditton." Diameter of plunger 36½", of bucket 51½, stroke 120". The pumps receive water through a 50" pipe, and discharge through a 36" main. Air chambers of ample capacity are located near the pumps. The pump valves are "Cornish equilibrium." There are 11 suction and 10 discharge valves. Diameter of lower seats 16", of upper 13⅜", lift of valves 1⅛". There is also a large bucket valve of the same kind. The lower seat is 40½", the upper 34½" diameter, the lift 4". The steam valve gear is of the kind known as "Sickel's," and the cut-off is worked from the parallel motion. Diameter of fly-wheel 26 feet, weight 30 tons. The head against which these pumps work is about 200 ft., and the capacity 17,000,000 United States gallons in 24 hours. These engines were contracted for at $188,800, in accordance with proposal made February 15, 1868, by the Knapp Fort Pitt Foundry Company, of Pittsburg, Pa., and were finished in 1870. They have been very satisfactory. The consumption of steam is 25 pounds per indicated horse power per hour, the rate of expansion from 3 to 4, the number of revolutions per minute 11½, though they have been run on a trial at 14¼. Steam is usually furnished to each engine by six boilers, each with internal fire place and return flues. The grate surface is 25 square feet, the heating surface 500 square feet to each boiler. The steam pressure is 40 pounds per square inch.

The fourth type of engine is No. 3, high service engine. This engine works against the same head as the other high service engines, but has a capacity of 1,000,000 gallons per hour. The engine is a double beam compound engine. There are two high pressure steam cylinders unjacketed, 50"×87". The low pressure cylinders 80"×138¼", the cranks are set at right angles on a shaft which carries a fly-wheel 32 ft. diameter, weight 35 tons. The air-pumps are double-acting, each 23"×54". The main pumps are each of the "Thames Ditton" kind, plungers 32", buckets 45¼" diameter, and 100" stroke. The pump valves are "Cornish equilibrium," and the steam valves are driven by spur gearing on the shaft. The action of the pumps is exceedingly smooth. The contract for these engines was awarded to the Hartford Foundry and Machine Company, on March 19, 1873, for $280,000, and was finished in 1874.

WORTHINGTON'S DUPLEX PUMPING ENGINES.

Designed by HENRY R. WORTHINGTON, M. E.

The pumps are in pairs, horizontal and double-acting, arranged side by side on the same frame, each operated directly by a compound engine with steam jacketed cylinders. The smaller steam cylinder is attached to the front head of the larger, and has a central piston rod connecting with pump rod through a cross-head, and two piston rods from the larger cylinder pass outside the smaller and connect with the cross-head. There are two single-acting air-pumps, which are operated from the ends of a horizontal beam, with vertical lever attached, receiving motion from one main cross-head. The main valves are plain slides operating over double cylinder ports.

The valves for both cylinders of each engine are arranged on the same stem by raising the chest of the smaller, and each valve is provided with a balancing piston. The valves of one engine are operated by bell cranks directly from the reciprocating parts of the other, and no rotative movements, with accompanying details, are required. Double cylinder ports are provided—the outer ones receive steam past the ends of the valves, and admit same to the cylinder in the usual way; the inner ones communicate with the exhaust cavity of the valve only, and enter the cylinder at such distances from the ends that when steam is exhausting through one of the ports the main piston will run over and close it, and cushion upon the vapor thereby inclosed, the outer port being at the time shut off by the main valve. Valves are provided to put the two cylinder ports at each end in communication to regulate the extent of cushioning. The pump valves consist of rubber disks arranged in chambers above and below the plungers. Each plunger runs, without packing, in a long grooved ring in a central diaphragm. In operation, one engine, while in full action, moves the valves of the other, when the pistons of the latter gradually begin to move, and finally attain full velocity, as those of the first are checked by the steam cushions and gradually come to rest, the pump valves meantime seating quietly.

HOLYOKE DAM AND CANAL.

The dam across the Connecticut, at South Hadley Falls, was constructed for the supply of water-power to the proposed town of Holyoke, which, since its construction, has developed into a large manufacturing city. The dam, as originally constructed, was 1,017 feet between abutments, with an average height of 30 feet, with a base of 80 feet. It was constructed of timber crib-work, loaded with stone for about one-third of its height. The foot of each rafter is bolted to the ledge underlying the whole dam, and all timbers at their intersections are tree-nailed together with 2-inch white oak treenails. The inclined plank face is loaded with gravel, and the joint at the ledge secured with concrete. The base tiers of ranging timber were 15×15 in., other timbers were 12×12 in. The rafters are placed vertically over each other in bents, 6 feet between centers. The planking was of hemlock, 6 inches thick, with oak cross-planking at crest, of 4 inches thick at bottom and 8 inches at top. The crest was plated with ¼ inch iron, 5 feet wide. During the construction, the dam was first planked about 30 feet on the incline. A space was then left about 16 feet deep on line of incline, and of length sufficient to vent the flow of the stream. This aperture was closed by a plank flap, as soon as the dam was ready for the filling of the reservoir. The highest freshet has given over 12 feet depth over the crest. By the action of the water flowing over the crest, the ledge beneath, after a few years, began to be worn and cut out, to the manifest insecurity of the work; there was, therefore, a roll made of similar construction to that of the main dam, that is, loaded crib work and plank face, which gives a discharge at a distance from the structure, and secured its stability. The water power supplied by this dam is perhaps the largest in the United States, utilizing the whole water power of the Connecticut River, with a fall of about 60 feet.

DAM ACROSS THE MOHAWK AT COHOES, N. Y.

Designed by W. E. WORTHEN, C.E.

The Cohoes dam across the Mohawk is a stone roll to an old crib dam, which had become very leaky and worn, and which, by its overfall, had worn deeply into the ledge of slate stone on which it was constructed. The old dam was left as a sort of coffer-dam for the construction of the new dam, and for a protection to it from the shocks of ice. The exterior of the dam was rock-faced ashlar, below, and the capstones were in single lengths of 10 feet, and not less than 2 feet wide by 15 inches thick. They were doweled together by 2 galvanized wrought iron dowels. The hearting of the work was of small stone, such as be readily laid by one man; the whole work was laid very carefully and full in cement mortar. The capstones were bedded in cement, and joints filled to within 6 inches of top, which was then run full of sulphur. The length of the dam is 1,380 feet, with an average depth of 12 feet below crest of dam. In the construction of the dam the leak of the old dam was stopped as far as possible, by a sheet piling attached to the face of the old dam, and another sheet piling parallel with it, and 18 to 20 inches distant; the joints of this last with the ledge were made tight by sausages, or long bags, about six inches diameter, filled with dry sand and cement, forced down along the line of ledge, and the spaces between the pilings were divided from time to time by cross-pilings, which made a series of boxes of such sizes as could be readily filled at once by batches of concrete. After the setting of the concrete, all pilings except on face of old dam were removed, and the spaces filled in with grout, and the concrete became a part of the dam. The work was begun July 14, 1865, and on October 20 of the same year, it was complete, with the exception of 20 feet of coping. The dam at Cohoes, though of insignificant height, utilizes a fall of about 130 feet, and a minimum flow of about 1,000 cubic feet per second.

PREPARING GELATINE EMULSION.

By PHOTO-CHEMICUS.

A DEBT of gratitude is certainly due to your correspondent Mr. Jarman, for the liberal manner in which he has stopped a gap for the benefit of his professional brethren, by his most lucid explanation of the process of preparing and working gelatine emulsion plates. His paper is exactly the right thing at the right time; and, so far from complaining that he has repeated a "thrice told tale," I feel sure that your readers will heartily welcome any—even the most trivial—details in connection with a process which, having slumbered for so many years since its invention by Dr. Maddox, has now come suddenly to the front in a manner which threatens to revolutionize the whole practice of photography.

I sincerely trust that every worker in this department will freely add their experiences to those of Mr. Jarman, as they may fully depend that no information they have gained by practice can be too trivial to interest their fellow-workers.

With this feeling, I am induced to add my mite to the common stock, my special object now being to simplify Mr. Jarman's process for the benefit of brother amateurs.

The plan I propose involves no outlay for apparatus of any kind, and enables us to carry the whole process nearly through in daylight. It is as follows: Having prepared, set, cut up, and washed the emulsion (the latter by Wratten and Wainwright's method), I melt it, and pour it into a common stoneware ink bottle, cork this down, and, for still greater security, tie the cork over with leather. I then immerse this in an ordinary saucepan containing water from 90° to 100°. I then bring this out of the dark room into one in which it may be constantly under my observation, and by means of the smallest possible light from a Bunsen burner (and it is astonishing how little heat is required), keep it for three, four, or five days at the required temperature. Where gas is not available, a night light, or perhaps even two, under the saucepan answer equally well. Test the temperature occasionally, taking precautions that the heat shall not rise much above 100°, and fill up, as evaporation occurs, with warm water.

When digested sufficiently long, take the jar back into the dark room, and it is ready for use. The jar may be opened at any time, and a plate coated, exposed, and developed, as an experiment. Of course the process may be reversed, and the washing, etc., done after the digestion; but I prefer the former plan.

The question is often asked why the effect of long digestion should be to increase the sensitiveness of the emulsion. The reason appears to be that when first made it is probably a simple solution of gelatine, in which silver bromide is *mechanically* suspended, and that the effect of digestion at increased temperature is to create a *chemical* combination in which silver bromide is no longer the active agent, but a compound of the organic matter, bromine and silver—in fact, what may be called "organo-bromide of silver." Now as, in a general way, organic salts of metals are much more readily decomposed by chemical agents (light being a most powerful one) than inorganic, the silver salt so created is much more readily reduced than the stable silver bromide. Hence each day's digestion renders the solution more sensitive, because every hour is creating more of the triple combination, and (*theoretically*, at least) the most perfect emulsion would be that in which this combination had been carried to its utmost limit; but *practically* this point is not likely to be attained, as decomposition would probably occur before such limit was reached.—*Photographic News.*

THE GELATINO-BROMIDE PROCESS.

By A. J. JARMAN.

ALREADY I have received a large number of letters asking if I supply plates and emulsion, and what kind of drying box I use. At present I am not in a position to undertake the manufacture of plates on a large scale, my main object being to give all the necessary instruction, as far as I am able, so that photographers may prepare their own plates; and I sincerely hope that by following every description, they will succeed as well as I have done.

Fig. 1 gives a sectional view of the drying box. A is a zinc tube four inches in diameter; B is a zinc tube two inches diameter; C is a small gas jet that burns in the bottom of the tube B, and warms the said tube, thereby causing the air that passes up A to become slightly warmed, and passes over the first shelf of plates, and so on to the bottom of the box, and passes out by the tube B. It will be seen that the air *must* pass through the box before it can supply the gas flame. If cold draught is required, light the top burner, D, and if required to dry spontaneously, then break up some quicklime, about the size of cracking nuts, and three parts fill the two trays shown in sketch; close the door, and in about two days the whole box of plates are nicely dried.

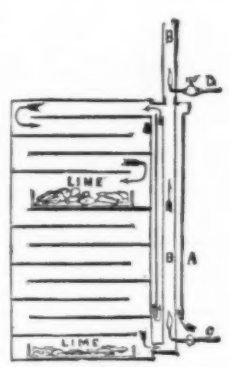


Fig. 1.

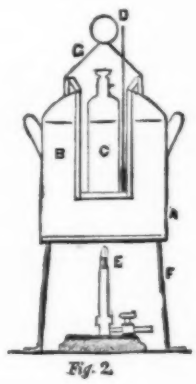


Fig. 2.

Fig. 2 gives a sectional view of my emulsion kettle. The sketch will explain itself. A is the kettle, B the earthen jar, C the bottle containing the emulsion, D the thermometer, E gas jet, F three legged iron stand. G is a conical lid, so that a large necked bottle can be used for the emulsion.

Fig. 3 is exactly the ruby lantern I use. It is made to rest on the top of a Silber paraffin burner; three sides are fitted with *deep* ruby glass, six inches by four inches; the back part is fitted with a door; the chimney is that of an ordinary magic lantern, which, by the elbow, stops the light from striking the ceiling of the room.

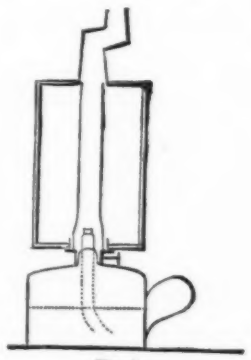


Fig 3.

I sincerely hope the above sketches and description I have given may prove themselves of value to all photographers who have been seeking practical information for working the gelatino-bromide process.

PREDICTION OF THE WEATHER.

By Professor KLINKERFUSS.

THE author gives the following conclusions: The dew-point read off at sunset indicates the minimum temperature for the night. If the dew-point is below 0°, and the sky clear, frost is to be expected. If it is about 5° below the mean temperature for the day, a cold and dry current of air is approaching. Inversely, a high dew-point indicates that a warm and moist current is approaching, when the air may easily reach its point of saturation, rain then being the result. If, in a day hotter than the average, the dew-point equals or exceeds this temperature, thunderstorms may be expected, on account of the quantity of condensed vapor. If the dew-point rises to 20° C., hail may be expected.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SARATOGA MEETING, AUGUST, 1879.

HISTORY AND METHODS OF PALÆONTOLOGICAL DISCOVERY.*

By PROFESSOR O. C. MARSH, President.

IN the rapid progress of knowledge, we are constantly brought face to face with the question, What is life? The answer is not yet, but a thousand earnest seekers after truth seem to be slowly approaching a solution. This question gives a new interest to every department of science that relates to life in any form, and the history of life offers a most suggestive field for research. One line of investigation lies through embryology, and here the advance is most encouraging. Another promising path leads back through the life history of the globe, and in this direction we may hope for increasing light, as a reward for patient work.

The plants and animals now living on the earth interest alike the savage and the savant, and hence have been carefully observed in every age of human history. The life of the remote past, however, is preserved only in scanty records, buried in the earth, and therefore readily escapes attention. For these reasons, the study of ancient life is one of the latest of modern sciences, and among the most difficult. In view of the great advances which this department of knowledge has made within the last decade, especially in this country, I have thought it fitting to the present occasion to review briefly its development, and have chosen for my subject this evening, "The History and Methods of Palæontological Discovery."

In the short time now at my command I can only attempt to present a rapid sketch of the principal steps in the progress of this science. The literature of the subject, especially in connection with the discussions it provoked, is voluminous, and an outline of the history itself must suffice for my present purpose.

In looking over the records of palæontology, its history may conveniently be divided into four periods, well marked by prominent features, but, like all stages of intellectual growth, without definite boundaries.

The first period, dating back to the time when men first noticed fossil remains in the rocks, and queried as to their nature, is of special interest in this connection. The most prominent characteristic of this period was a long and bitter contest as to the *nature of fossil remains*. Were they mere "sports of Nature," or had they once been endowed with life? Simple as this problem now seems, centuries passed before the wise men of that time were agreed upon its solution.

Sea shells in the solid rock on the tops of mountains early attracted the attention of the ancients, and the learned men among them seem to have appreciated in some instances their true character, and given rational explanations of their presence.

The philosopher Zenophanes, of Colophon, who lived about 500 B. C., mentions the remains of fishes and other animals in the stone quarries near Syracuse, the impression of an anchovy in the rock of Paros, and various marine fossils at other places. His conclusion from these facts was, that the surface of the earth had once been in a soft condition at the bottom of the sea, and thus the objects mentioned were entombed. Herodotus, half a century later, speaks of marine shells on the hills of Egypt and over the Libyan desert, and he inferred therefrom that the sea had once covered that whole region. Empedocles, of Agrigentum (450 B. C.), believed that the many hippopotamus bones found in Sicily were remains of human giants, in comparison with which the present race were as children. Here, he thought, was a battle field between the gods and the Titans, and the bones belonged to the slain. Pythagoras (582 B. C.) had already anticipated one conclusion of modern geology, if the following statement, attributed to him by Ovid, was his own:*

> "Vidi ego quod fuerat solidissima tellus,
> Esse fretum: vidi factas ex æquore terras;
> Et procul a pelago conchæ jacuere marinæ."

Aristotle (384–322 B. C.) was not only aware of the existence of fossils in the rocks, but has also placed on record sagacious views as to the changes in the earth's surface necessary to account for them. In the second book of his Meteorics, he says: "The changes of the earth are so slow in comparison to the duration of our lives, that they are overlooked; and the migrations of people after great catastrophes and their removal to other regions, cause the event to be forgotten." Again, in the same work, he says: "As time never fails, and the universe is eternal, neither the Tanais, nor the Nile, can have flowed for ever. The places where they rise were once dry, and there is a limit to their operations: but there is none to time. So of all other rivers; they spring up, and they perish; and the sea also continually deserts some lands and invades others. The same tracts, therefore, of the earth are not, some always sea, and others always continents, but everything changes in the course of time."

Aristotle's views on the subject of spontaneous generation were less sound, and his doctrines on this subject exerted a powerful influence for the succeeding twenty centuries. In the long discussion that followed concerning the nature of fossil remains, Aristotle's views were paramount. He believed that animals could originate from moist earth or the slime of rivers, and this seemed to the people of that period a much simpler way of accounting for the remains of animals in the rocks than the marvelous changes of sea and land otherwise required to explain their presence. Aristotle's opinion was in accordance with the Biblical account of the creation of man out of the dust of the earth, and hence more readily obtained credence.

Theophrastus, a pupil of Aristotle, alludes to fossil fishes found near Heraclea, in Pontus, and in Paphlagonia, and says: "They were either developed from fish spawn left behind in the earth, or gone astray from rivers or the sea into cavities of the earth, where they had become petrified." In treating of fossil ivory and bones, the same writer supposed them to be produced by a certain plastic virtue latent in the earth. To this same cause, as we shall see, many later authors attributed the origin of all fossil remains.

Previous to this Anaximander, the Miletian philosopher, who was born about 610 years before Christ, had expressed essentially the same view. According to both Plutarch and Censorinus, Anaximander taught that fishes, or animals very like fishes, sprang from heated water and earth, and from these animals came the human race; a statement which can hardly be considered as anticipating the modern idea of evolution, as some authors have imagined.

The Romans added but little to the knowledge possessed by the Greeks in regard to fossil remains. Pliny (23–79 A. D.), however, seems to have examined such objects with interest, and in his renowned work on Natural History gave names to several forms. He doubtless borrowed largely from Theophrastus, who wrote about three hundred years before. Among the objects named by Pliny were, "*Bucardia*, like to an ox's heart;" "*Brontia*, resembling the head of a tortoise, supposed to fall in thunderstorms;" "*Glossoptra*, similar to a human tongue, which does not grow in the earth, but falls from heaven while the moon is eclipsed;" "the *Horn of Ammon*, possessing, with a golden color, the figure of a ram's horn;" *Ceraunia* and *Ombria*, supposed to be thunderbolts; *Ostracites*, resembling the oyster shell; *Spongites*, having the form of sponge; *Phycites*, resembling sea-weed or rushes. He also mentions stones resembling the teeth of hippopotamus; and says that Theophrastus speaks of fossil ivory, both black and white, of bones born in the earth, and of stones bearing the figure of bones.

Tertullian (160 A. D.) mentions instances of the remains of sea animals on the mountains, far from the sea, but uses them as a proof of the general deluge recorded in Scripture.

During the next thirteen or fourteen centuries fossil remains of animals and plants seemed to have attracted so little attention that few references are made to them by the writers of this period. During these ages of darkness all departments of knowledge suffered alike, and feeble repetitions of ideas derived from the ancients seem to have been about the only contributions of that period of natural science.

Albert the Great (1205–1280 A. D.), the most learned man of his time, mentions that a branch of a tree was found, on which was a bird's nest containing birds, the whole being solid stone. He accounted for this strange phenomenon by the *vis formativa* of Aristotle, an occult force, which, according to the prevalent notions of the time, was capable of forming most of the extraordinary objects discovered in the earth.

Alexander *ab Alexandro*, of Naples, states that he saw in the mountains of Calabria, a considerable distance from the sea, a variegated hard marble, in which many sea shells but little changed were heaped, forming one mass with the marble.

With the beginning of the sixteenth century a great impetus was given to the investigation of organic fossils, especially in Italy, where this study really began. The discovery of fossil shells, which abound in this region, now attracted great attention, and a fierce discussion soon arose as to the true nature of these and other remains. The ideas of Aristotle in regard to spontaneous generation, and especially his view of the hidden forces of the earth, which he claimed had power to produce such remains, now for the first time were seriously questioned, although it was not till nearly two centuries later that these doctrines lost their dominant influence.

Leonardo da Vinci, the renowned painter and philosopher, who was born in 1452, strongly opposed the commonly accepted opinions as to the origin of organized fossils. He claimed that the fossil shells under discussion were what they seemed, and had once lived at the bottom of the sea. "You tell me," he says, "that nature and the influence of the stars have formed these shells in the mountains; then show me a place in the mountains where the stars at the present day make shelly forms of different ages and of different species in the same place." Again he says: "In what manner can such a cause account for the petrifactions in the same place of various leaves, sea-weeds, and marine crabs?"

In 1517, excavations in the vicinity of Verona brought to light many curious petrifactions, which led to much speculation as to their nature and origin. Among the various authors who wrote on this subject was Fracastoro, who declared that the fossils once belonged to living animals, which had lived and multiplied where found. He ridiculed the prevailing ideas that the plastic force of the ancients could fashion stones into organic forms. Some writers claimed that these shells had been left by Noah's flood, but to this idea Fracastoro offered a mass of evidence, which would now seem conclusive, but which then only aroused bitter hostility. That inundation, he said, was too transient; it consisted mainly of fresh water, and, if it had transported shells to great distances, must have scattered them over the surface, not buried them in the interior of mountains.

Conrad Gesner (1516–1565), whose history of animals has been considered the basis of modern zoology, published at Zurich in 1565 a small but important work entitled "De rerum Fossilium, Lapidium, et Gemmarum figuris." It contained a catalogue of the collection of fossils made by John Kentmann. This is the oldest catalogue of fossils with which I am acquainted.

George Agricola (1494–1555) was, according to Cuvier, the first mineralogist who appeared after the revival of learning in Europe. In his great work, "De Re Metalica," published in 1546, he mentions various fossil remains, and says they were produced by a certain "*materia pinguis*," or fatty matter, set in fermentation by heat. Some years later Bauhin published a descriptive catalogue of the fossils he had collected in the neighborhood of Boll, in Wirtemberg.*

Andrew Mattioli, a distinguished botanist, adopted Agricola's notion as to the origin of organized fossils, but admitted that shells and bones might be turned into stone by being permeated by a "lapidifying juice." Falloppio, the eminent professor of anatomy at Padua, believed that fossil shells were generated by fermentation where they were found; and that the tusks of elephants, dug up near Apulia, were merely earthy concretions. Mercati, in 1574, published figures of the fossil shells preserved in the Museum of the Vatican, but expressed the opinion that they were only stones that owed their peculiar shapes to the heavenly bodies. Olivi, of Cremona, described the fossils in the Museum of Verona, and considered them all "sports of nature."

Palissy, a French author, in 1580, opposed these views, and is said to have been the first to assert in Paris that fossil shells and fishes had once belonged to marine animals. Fabio Colonna appears to have first pointed out that some of the fossil shells found in Italy were marine and some terrestrial.

Another peculiar theory discussed in the sixteenth century deserves mention. This was the vegetation theory, especially advocated by Tournefort and Camerarius, both eminent as botanists. These writers believed that the seeds of minerals and fossils were diffused throughout the sea and the earth, and were developed into their peculiar forms by the regular increment of their particles, similar to the formation of crystals. "How could the *Cornu Ammonis*," Tournefort asked, "which is constantly in the figure of a volute, be formed without a seed containing the same structure in the small as in the larger forms?" Who moulded it so artfully, and where are the moulds? The stalactites which formed in caverns in various parts of the world were also supposed to be proofs of this vegetative growth.

Still another theory has been held at various times, and is not yet entirely forgotten, namely, that the Creator made fossil animals and plants just as they are found in the rocks, in pursuance of a plan beyond our comprehension. This theory has never prevailed among those familiar with scientific facts, and hence needs here no further consideration.

An interest in fossil remains arose in England later than on the continent; but when attention was directed to them, the first opinions as to their origin were not less fanciful and erroneous than those to which we have already referred. Dr. Plot, in his "Natural History of Oxfordshire," published in 1677, considered the origin of fossil shells and fishes to be due to a "plastic virtue, latent in the earth," as Theophrastus had suggested long before. Lhwyd, in his "Lithophylacii Britannici Ichnographia," published at Oxford in 1699, gives a catalogue of English fossils contained in the Ashmolean Museum. He opposed the *vis plastica* theory, and expressed the opinion that the spawn of fishes and other marine animals had been raised with the vapors from the sea, conveyed inland by clouds and deposited by rain, had permeated into the interior of the earth, and thus produced the fossil remains we find in the rocks. About this time several important works were published in England by Dr. Martin Lister, which did much to infuse a true knowledge of fossil remains. He gave figures of recent shells side by side with some of the fossil forms, so that the resemblance became at once apparent. The fossil species of shells he called "turbinated and bivalve stones," and adds, "either these were terriginous, or, if otherwise, the animals which they so exactly represent have become extinct."

During the seventeenth century there was a considerable advance in the study of fossil remains. The discussions in regard to the nature and origin of these objects had called attention to them, and many collections were now made, especially in Italy, and also in Germany, where a strong interest in this subject had been aroused. Catalogues of these collections were not unfrequently published, and some of them were illustrated with such accurate figures, that many of the species can now be readily recognized. In this century, too, an important step in advance was made by the collection and description of fossils from particular localities and regions, in distinction from general collections of curiosities.

Casper Schwenkfeld, in 1600, published a catalogue of the fossils discovered in Silesia; in 1622, a detailed description of the renowned Museum of Calceolarius, of Verona, appeared; and in 1642, a catalogue of Besler's collection; Warmius' catalogue was published in 1652; Spener's in 1663; and Septala's in 1666. A description of the Museum of the King of Denmark was issued in 1669; Cottorp's catalogue in 1674, and that of the renowned Kirscher in 1678. Dr. Grew gave an account in 1687 of the specimens in the Museum of Gresham's College in England; and in 1695, Petiver of London published a catalogue of his very extensive collection. A catalogue by Fred. Lauchmund, on the fossils of Hildesheim, appeared in 1669, and the fossils of Switzerland were described by John Jacob Wagner in 1689. Among similar works were the dissertations of Gyer, at Frankfort, and Albertus at Leipsic.

Steno, a Dane, who had been professor of anatomy at Padua, published, in 1669, one of the most important works of this period.* He entered earnestly into the controversy as to the origin of fossil remains, and by dissecting a shark from the Mediterranean, proved that its teeth were identical with some found fossil in Tuscany. He also compared the fossil shells found in Italy with existing species, and pointed out their resemblance. In the same work, Steno expressed some very important views in regard to the different kinds of strata and their origin, and first placed on record the important fact that the oldest rocks contain no fossils.

Scilla, the Sicilian painter, published, in 1670, a work on the fossils of Calabria, well illustrated. He is very severe against those who doubted the organic origin of fossils, but is inclined to consider them relics of the Mosaic deluge.

Another instance of the power of the *lusus naturæ* theory, even at the close of the seventeenth century, deserves mention. In the year 1696, the skeleton of a fossil elephant was dug up at Tonna, near Gotha, in Germany, and was described by William Ernest Tentzel, a teacher in the Gotha Gymnasium. He declared the bones to be the remains of an animal that had lived long before. The medical faculty in Gotha, however, considered the subject, and decided officially that this specimen was only a freak of nature.

Besides the authors I have mentioned, there were many others who wrote about fossil remains before the close of the seventeenth century, and took part in the general discussion as to their nature and origin. During the progress of this controversy the most fantastic theories were broached and stoutly defended, and although refuted from time to time by a few clear-headed men, continually sprang up anew, in the same or modified forms. The influence of Aristotle's views of equivocal generation, and especially the scholastic tendency to disputation, so prevalent during the Middle Ages, had contributed largely to the retardation of progress, and yet a real advance in knowledge had been made. The long contest in regard to the nature of fossil remains was essentially over, for the more intelligent opinion at the time now acknowledged that these objects were not mere "sports of nature," but had once been endowed with life. At this point therefore, the first period in the history of palæontology, as I have indicated it, may appropriately end.

It is true that later still the old exploded errors about the plastic force and fermentation were from time to time revived, as they have been almost to the present day; but learned men, with few exceptions, no longer seriously questioned that fossils were real organisms, as the ancients had once believed. The many collections of fossils that had been brought together, and the illustrated works that had been published about them, were a foundation for greater progress, and, with the eighteenth century, the second period in the history of palæontology began.

The main characteristic of this period was the general belief that *fossil remains were deposited by the Mosaic deluge*. We have seen that this view had already been advanced, but it was not till the beginning of the eighteenth century

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* An address delivered before the American Association for the Advancement of Science, at Saratoga, N. Y., August 28, 1879.

† Metamorphoses, Liber XV., 262.

* "Historia novi et admirabilis Fontis Balneique Bollensis, in Ducata Wirtembergico." Montbeliard, 1595.

* "De Solido intra Solidum naturaliter Contento."

that it became the prevailing view. This doctrine was strongly opposed by some courageous men, and the discussion on the subject soon became even more bitter than the previous one, as to the nature of fossils.

In this diluvial discussion theologians and laymen alike took part. For nearly a century the former had it all their own way, for the general public, then as now, believed what they were taught. Noah's flood was thought to have been universal, and was the only general catastrophe of which the people of that day had any knowledge or conception.

The scholars among them were of course familiar with the accounts of Deucalion and his ark, in a previous deluge, as we are to-day with similar traditions held by various races of men. The firm belief that the earth and all it contains was created in six days; that all life on the globe was destroyed by the deluge, excepting alone what Noah saved; and that the earth and its inhabitants were to be destroyed by fire, was the foundation on which all knowledge of the earth was based. With such fixed opinions, the fossil remains of animals and plants were naturally regarded as relics left by the flood described in Holy Writ. The dominant nature of this belief is seen in nearly all the literature in regard to fossils published at this time, and some of the works which then appeared have become famous on this account.

In 1710, David Büttner published a volume entitled "Rudera Diluvii Testes." He strongly opposed Lhwyd's explanation of the origin of fossils, and referred these objects directly to the flood. The most renowned work, however, of this time was published at Zurich, in 1726, by Scheuchzer, a physician and naturalist, and professor in the University of Altorf. It bore the title "Homo Diluvii Testis." The specimen upon which this work was based was found at Oeningen, and was regarded as the skeleton of a child destroyed by the deluge. The author recognized in this remarkable fossil, not merely the skeleton, but also portions of the muscles, the liver, and the brain. The same author was fortunate enough to discover, subsequently, near Altorf, two fossil vertebræ, which he at once referred to that "accursed race destroyed by the flood!" These, also, he carefully described and figured in his "Physica Sacra," published at Ulm in 1731. Engravings of both were subsequently given in the "Copper Bible." Cuvier afterward examined these interesting relics, and pronounced the skeleton of the supposed child to be the remains of a gigantic salamander, and the two vertebræ to be those of an ichthyosaurus!

Another famous book appeared in Germany in the same year in which Scheuchzer's first volume was published. The author was John Bartholomew Adam Beringer, professor at the University of Würtzburg, and his great work* indirectly had an important influence upon the investigation of fossil remains. The history of the work is instructive, if only as an indication of the state of knowledge at that date. Professor Beringer, in accordance with views of his time, had taught his pupils that fossil remains, or "figured stones," as they were called, were mere "sports of Nature." Some of his fun-loving students reasoned among themselves, "If Nature can make figured stones in sport, why can not we?" Accordingly, from the soft limestone in the neighboring hills, they carved out figures of marvelous and fantastic forms, and buried them at the localities where the learned professor was accustomed to dig for his fossil treasures. His delight at the discovery of these strange forms encouraged further production, and taxed the ingenuity of these youthful imitators of Nature's secret processes. At last Beringer had a large and unique collection of forms, new to him and to science, which he determined to publish to the world. After long and patient study, his work appeared, in Latin, dedicated to the reigning prince of the country, and illustrated with twenty-one folio plates. Soon after the book was published, the deception practiced upon the credulous professor became known; and, in place of the glory he expected from his great undertaking, he received only ridicule and disgrace. He at once endeavored to repurchase and destroy the volumes already issued, and succeeded so far that few copies of the first edition remain. His small fortune, which had been seriously impaired in bringing out his grand work, was exhausted in the effort to regain what was already issued, as the price rapidly advanced in proportion as fewer copies remained; and, mortified at the failure of his life's work, he died in poverty. It is said that some of his family, dissatisfied with the misfortune brought upon them by this disgrace and the loss of their patrimony, used a remaining copy for the production of a second edition, which met with a large sale, sufficient to repair the previous loss and restore the family fortune. This work of Beringer, in the end, exerted an excellent influence upon the dawning science of fossil remains. Observers became more cautious in announcing supposed discoveries, and careful study of natural objects gradually replaced vague hypotheses.

The above works, however, are hardly fair examples of the literature on fossils during this part of the eighteenth century. Scheuchzer had previously published his well-known "Complaint and Vindication of the Fishes," illustrated with good plates. Moro, in his work on "Marine Bodies which are Found in the Mountains," 1740, showed the effects of volcanic action in elevating strata and causing faults. Vallisneri had studied with care the marine deposits of Italy. Donati, in 1750, had investigated the Adriatic, and ascertained by soundings that shells and corals were being embedded in the deposits there, just as they were found in the rocks.

John Gesner's dissertation, "De Petrificatis," published at Leyden in 1758, was a valuable contribution to the science. He enumerated the various kinds of fossils, and the different conditions in which they are found petrified, and stated that some of them, like those at Oeningen, resembled the shells, fishes, and plants of the neighboring region, while others, such as Ammonites and Belemnites, were either unknown species, or those found only in distant seas. He discusses the structure of the earth at length, and speculates as to the causes of changes in sea and land. He estimates that, at the observed rate of recession of the ocean, to allow the Apennines, whose summits are filled with marine shells, to reach their present height, would have taken about eighty thousand years, a period more than "ten times greater than the age of the universe." He accordingly refers the change to the direct command of the Deity, as related by Moses, that, "The waters should be gathered together in one place, and the dry land appear."

Voltaire (1694–1778) discussed geological questions and the nature of fossils in several of his works, but his published opinions are far from consistent. He ridiculed effectively and justly the cosmogonists of his day, and showed, also, that he knew the true nature of organic remains. Finding, however, that theologians used these objects to confirm the Scriptural account of the deluge, he changed his views, and accounted for fossil shells found in the Alps, by suggesting that they were Eastern species, dropped by the pilgrims on their return from the Holy Land!

Buffon, in 1749, published his important work on Natural History, and included in it his "Theory of the Earth," in which he discussed, with much ability, many points in geology. Soon after the book was published, he received an official letter from the Faculty of Theology in Paris, stating that fourteen propositions in his works were reprehensible, and contrary to the creed of the church. The first objectionable proposition was as follows: "The waters of the sea have produced the mountains and valleys of the land—the waters of the heavens, reducing all to a level, will at last deliver the whole land over to the sea, and the sea successively prevailing over the land, will leave dry new continents like those we inhabit."

Buffon was politely invited by the college to recant, and having no particular desire to be a martyr to science, submitted the following declaration, which he was required to publish in his next work: "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact; and I abandon everything in my book respecting the formation of the earth, and, generally, all which may be contrary to the narration of Moses."

This single instance will suffice to indicate one great obstacle to the advancement of science, even up to the middle of the eighteenth century.

Another important work appeared in France about this time, Bourguet's "Traité des Petrifactions," published in 1758, which is well illustrated with faithful plates. In England, a discourse on earthquakes, by Dr. Robert Hooke, was published in 1705. This author held some views in advance of his time, and maintained that figured stones were "really the several bodies they represent or the mouldings of them petrified, and not, as some have imagined, a *lusus naturæ*, sporting herself in the needless formation of useless things." He anticipates one important conclusion from fossils, when he states that "though it must be very difficult to read them and to raise a chronology out of them, and to state the intervals of time wherein such or such catastrophes and mutations have happened, yet it is not impossible." He also states that fossil turtles and such large Ammonites as are found in Portland, seem to have been the productions of hotter countries, and hence it is necessary to suppose that England once lay under the sea within the torrid zone. He seems to have suspected that some of the fossils of England belonged to extinct species, but thought possibly they might be found living in the bottom of distant oceans.

Dr. Woodward's "Natural History of the Fossils of England" appeared in 1729. This work was based on a systematic collection of fossils which he had brought together, and which he subsequently bequeathed to the University of Cambridge, where it is still preserved, with his arrangement carefully retained. This descriptive part of this work is interesting, but his conclusions are made to coincide strictly with the Scriptural account of the creation and deluge. He had previously stated, in another work, that he believed "the whole terrestrial globe to have been taken to pieces and dissolved at the flood, and the strata to have settled down from this promiscuous mass." In support of this view, he stated that, "Marine bodies are lodged in the strata according to the order of their gravity, the heavier shells in stones, the lighter in chalk, and so of the rest."*

The most important work on fossils published in Germany at this time was that of George Wolfgang Knorr, which was continued after his death by Walch. This work consisted of four folio volumes, with many plates, and was printed at Nuremberg, 1755–73. A large number of fossils were accurately figured and described, and the work is one of permanent value.† A French translation of this work appeared in 1767-78. Burton's "Oryctographie de Bruxelles," 1784, contains figures and descriptions of fossils found in Belgium.

Abraham Gottlieb Werner (1750–1817), Professor of Mineralogy at Freyberg, did much to advance the science of geology, and indirectly that of fossils. He first indicated the relations of the main formations to each other, and, according to his pupil, Professor Jameson, first made the highly important observation that "different formations can be discriminated by the petrifactions they contain." Moreover, that "the petrifactions contained in the oldest rocks are very different frem any of the species of the present time; that the newer the formation the more do the remains approach in form to the organic beings of the present creation." Unfortunately, Werner published little, and his doctrines were mainly disseminated by his enthusiastic pupils.

The great contest between the Vulcanists and the Neptunists started at this time, mainly through Werner, whose doctrines led to the controversy. The comparative merits of fire and water, as agencies in the formation of certain rocks, were discussed with a heat and acrimony characteristic of the subject and the time. Werner believed in the aqueous theory, while the igneous theory was especially advocated by Hutton of Edinburgh, and his illustrator, Playfair. This discussion resulted in the advancement of descriptive geology, but the study of fossils gained little thereby.

The "Protogæa" of Leibnitz, the great mathematician, published in 1749, about thirty years after his death, was a work of much merit. This author supposed that the earth had gradually cooled from a state of igneous fusion, and was subsequently covered with water. The subsidence of the lower part of the earth, the deposits of sedimentary strata from inundations, and their induration, as well as other changes, followed. All this, he supposed to have been accomplished in a period of six natural days. In the same work Leibnitz shows that he had examined fossils with considerable care.

Linnæus (1707–1778), the famous Swedish botanist, and the founder of the modern system of nomenclature in natural history, confined his attention almost entirely to the living forms. Although he was familiar with the literature of fossil remains, and had collected them himself, he did not include them in his system of plants and animals, but kept them separate, with the minerals; hence he did little directly to advance this branch of science.

During the last quarter of the eighteenth century, the belief that fossil remains were deposited by the deluge sensibly declined, and the dawn of a new era gradually appeared. Let us pause for a moment here, and see what real progress had been made; what foundations had been laid on which to establish a science of fossil remains.

The true nature of these objects had now been clearly determined. They were the remains of animals and plants. Most of them certainly were not the relics of the Mosaic deluge, but had been deposited long before, part in fresh water and part in the sea. Some indicated a mild climate, and some the tropics. That any of these were extinct species was as yet only suspected. Large collections of fossils had now been made, and valuable catalogues, well illustrated, had been published. Something was known, too, of the geological position of fossils. Steno, long before, had observed that the lowest rocks were without life. Lehmann had shown that above these primitive rocks, and derived from them, were the secondary strata, full of the records of life, and above these were alluvial deposits, which he referred to local floods and the deluge of Noah. Rouelle, Fuchsel, and Odoardi had shed new light on this subject. Werner had distinguished the transition rocks, containing fossil remains, between the primitive and the secondary, while everything above the chalk he grouped together, as "the overflowed land." Werner, as we have seen, had done more than this, if we give him the credit his pupils claim for him. He had found that the formations he examined contained each its own peculiar fossils, and from the older to the newer there was a gradual approach to recent forms. William Smith had worked out the same thing in England, and should equally divide the honor of this important discovery.

The greatest advance, however, up to this time, was that men now preferred to *observe*, rather than to *believe*, and facts were held in greater esteem than vague speculations. With the preparation for future progress, the second period in the history of palæontology, as I have divided it, may appropriately be considered at an end.

Thus far, I have said nothing in regard to one branch of my subject, the *methods* of palæontological research, for up to this time of method there was none. We have seen that those of the ancients who noticed marine shells in the solid rock, called them such, and concluded that they had been left there by the sea. The discovery of fossils led directly to theories of how the earth was formed. Here the progress was slow. Subterranean spirits were supposed to guard faithfully the mysteries of the earth; while above the earth, authority guarded with still greater power the secrets men in advance of their age sought to know. The dominant idea of the first sixteen centuries of the present era was that the universe was made for man. This was the great obstacle to the correct determination of the earth in the universe, and, later, of the age of the earth. The contest of astronomy against authority was long and severe, but the victory was at last with science. The contest of geology against the same power followed, and continued almost to our day. The result is still the same. In the early stages of this contest, there was no strife, for science was benumbed by the embrace of superstition and creed, and little could be done till that was cast off. In a superstitious age, when every natural event is referred to a supernatural cause, science cannot live; and often as the sacred fire may be kindled by courageous, far-seeing souls, will it be quenched by the dense mists of ignorance around it. Scarcely less fatal to the growth of science is the age of authority, as the past proves too well. With freedom of thought, came definite knowledge, and certain progress; but two thousand years was long to wait.

With the opening of the present century, began a new era in palæontology, which we may here distinguish as the third period in its history. This branch of knowledge became now a science. Method replaced disorder, and systematic study superseded casual observation. For the next half century the advance was continuous and rapid. One characteristic of this period was *the accurate determination of fossils by comparison with living forms.* This will separate it from the two former epochs. Another distinctive feature of this period was the general belief that *every species, recent and extinct, was a separate creation.*

At the very beginning of the epoch we are now to consider, three names stand out in bold relief: Cuvier, Lamarck, and William Smith. To these men, the science of palæontology owes its origin. Cuvier and Lamarck, in France, had all the power which great talent, education, and station could give; William Smith, an English surveyor, was without culture or influence. The last years of the eighteenth century had been spent by each of these men in preparation for his chosen work, and the results were now given to the world. Cuvier laid the foundation of the palæontology of vertebrate animals; Lamarck, of the invertebrates; and Smith established the principles of stratigraphical palæontology. The investigator of fossils to-day seldom needs to consult earlier authors of the science.

George Cuvier (1769–1832), the most famous naturalist of his time, was led to the study of extinct animals by ascertaining that the remains of fossil elephants he examined were extinct species. "This idea," he says later, "which I announced to the Institute in the month of January, 1796, opened to me views entirely new respecting the theory of the earth, and determined me to devote myself to the long researches and to the assiduous labors which have now occupied me for twenty-five years."*

It is interesting to note here that in this first investigation of fossil vertebrates, Cuvier employed the same method that gave him such important results in his later researches. Remains of elephants had been known to Europe for centuries, and many authors, from Pliny down to the contemporaries of Cuvier, had written about them. Some had regarded the bones as those of human giants, and those who recognized what they were, considered them remains of the elephants imported by Hannibal or the Romans. Cuvier, however, compared the fossils directly with the bones of existing elephants, and proved them to be distinct. The fact that these remains belonged to extinct species was of great importance. In the case of fossil shells, it was difficult to say that any particular form was not living in a distant ocean; but the two species of existing elephants, the Indian and the African, were well known, and there was hardly a possibility that another living one would be found.

(To be continued.)

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* "Lithographia Wirceburgensis, ducentis lapidum figuratorum, a potiori, insectiformium, prodigiosis imaginibus exornata." Wirceburgi, 1726. Edit. II. Francofurti et Lipsiæ. 1767.

* "Essay towards a Natural History of the Earth." 1695.

† "Lapides ex celeberr. viror. sententia diluvii universalis testes, quos in ordines ac species distribuit, suis coloribus expremit, etc." 272 Tab. 1755–73.

* "Ossemens Fossiles," Second Edition, vol. I., p. 178.

PHILOSOPHY OF THE PUPATION OF BUTTERFLIES.

By Prof. C. V. RILEY.

[Abstract of a Paper read before the American Association for the Advancement of Science.]

THE comparatively sudden transitions from one state to another in insects have always excited the keenest interest. The change from larva to chrysalis in those butterflies known as *suspensi*, and which in the chrysalis state hang from the tip of the body, has, perhaps, been looked upon as the most wonderful. The preliminary acts in the performance have been pretty well observed and described by various authors since the days of Vallisneri, the larva hanging by the anal end, turning up the anterior part of the body in a more or less complete curve, and the skin finally splitting from the head to the front edge of the metathoracic joint and being worked back in a shriveled mass toward the point of attachment. Now comes the critical feat which has most puzzled naturalists, viz., the independent attachment of the chrysalis and the withdrawal from and riddance of the larval skin which such attachment implies.

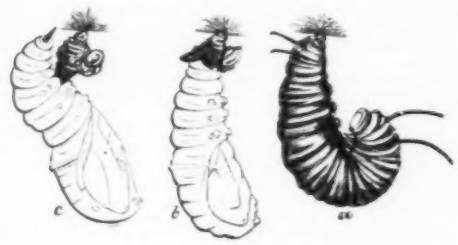


FIG. 1.—LARVA OF *DANAIS ARCHIPPUS*.

a, suspended; *b*, forming chrysalis with shriveled larval skin; *c*, method of holding to skin as formerly described.

Réaumur explained it in 1734 by the clutching of the larval skin between alternate sutures of the soft joints of the chrysalis, and his happy and circumspect account, from observations made on *Vanessa urticæ*, has formed the basis for subsequent accounts, or, at least, no one obtained a deeper insight into the philosophy of the act until, some two years since, Dr. J. A. Osborne, of Milford, England, discovered that a distinct membrane is concerned in it. In casual observations of the process I had long become convinced that the popular accounts were crude and inaccurate, and had preserved specimens in the act of transforming for future study; but the philosophy of the change cannot be satisfactorily made out from alcoholic specimens alone, nor from the study of one species. The present paper is based on observations made on species in more than a dozen genera, the conclusions having been partially presented last June to the Philosophical Society of Washington.

The body of the larva is composed (exclusive of the head) of 12 segments or joints *and a subjoint*. It is with this subjoint that we have here to deal, for to it are appended the anal prolegs beneath, and the anal plate above the rectum.

If we carefully examine the anal plate of the larvæ of the true *suspensi*, we shall find that while it differs in form it has one feature in common, viz., the being furnished dorsally and posteriorly with numerous short spines and points, generally retrorse, or so placed that the larva can make use of them in suspending. These special spines on the anal plate are only fully developed after the last larval moult, being more or less obsolete in the earlier stages, and they are also under muscular control. Even in the *succincti*, where, as a rule, the anal plate is not specialized, spines are nevertheless sparsely found, especially on the hind border.

All writers that I have consulted speak of the larval suspension being due to the entanglement of the hooks of the anal prolegs in the silk, and do not mention the use of the anal plate, for which the hillock of silk is sometimes spun in special form.*

The normal form may be likened to that of an inverted settee, or shoe, or to a ship knee, and one of the most interesting acts of the larva, preliminary to suspension, is the bending and working of the anal parts in order to fasten the back of the plate to the inside of the back of the settee, while the crotchets of the legs are entangled in the more flattened position or seat. In some cases (as in *Danais*) the hillock of silk is more elongate, and the spines of the truncate plate occur most around the lower margin, and even beneath it, so that in fastening them the larva seems to be drawing the silk up the rectum. In other cases (as in *Euptoieta*) the plate, in addition to the spines, has a prominent tubercle on each anterior outer border well calculated to lock securely into the silk. After suspension, and as the fluids gravitate anteriorly, the silken hillock becomes more conical (the threads being loosely spun and elastic), and the hooks both of the plate and the prolegs hang more loosely from it.

In the final getting rid of the larval skin and attachment of the chrysalis there are concerned:

1st. Certain features belonging to the larva and cast off with its skin; 2d. Those belonging to the chrysalis; and to intelligibly explain the process it is necessary to more fully characterize and homologize these parts than has hitherto been done.

In the former category, in addition to the natural adhesiveness of the moist, mucous, and membranous corium,

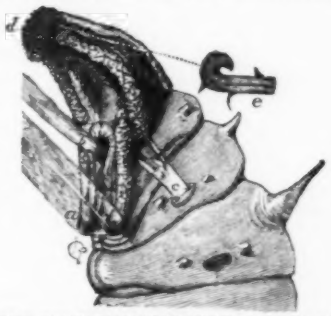


FIG. 3.—END OF CHRYSALIS OF *VANESSA ANTIOPA*, showing (*a*) the sustainers with retaining membrane indicated; (*b*) rectal ligament; (*c*) tracheal ligament; (*d*) cremastral hook-pad; (*e*) one of the hooks greatly enlarged. (After Riley.)

there are three physiological factors concerned: 1st. The *tracheal ligaments*, or the shed tracheæ from the last or ninth pair of spiracles, which uniformly become blind or obsolete in the chrysalis; 2d. The *rectal ligament*, or shed intestinal canal; 3d. The Osborne or retaining membrane (*membrana retenens*), which is but a stretched part of the membranous corium that accumulates around the rectum and in the anal prolegs, and that is intimately connected with the rectal ligament.

In the second category we have the structural features of the chrysalis. These are: *First*. The *cremaster* proper, which is the homologue of the anal plate of the larva, and the form of which is foreshadowed in that of said anal plate. This cremaster assumes a great variety of different forms, but in general may be said to be a tapering piece, more or less incurved ventrally, and having the ventral and dorsal margins thickened or ridged, and these ridges may be respectively called the *ventral* and the *dorsal cremastral ridges*. This cremaster is surmounted at the apex and sometimes along the ventral ridges by what may be called the *cremastral hook-pad*, thickly studded with minute but stout hooks, which are sometimes compound or furnished with barbs, very much as are some of our fishing hooks, and which are most admirably adapted to the purpose for which they are intended.

FIG. 2.—SHRUNKEN LARVAL SKIN OF *VANESSA ANTIOPA*, cut open from the back, and showing (*a*) the retaining membrane; (*b*) the rectal ligament; (*c*, *c*) the tracheal ligaments. (After Riley.) The connection between *a* and *b* is not sufficiently shown.

Secondly. We have the sustainers (*sustentores*), two projections which homologize with the soles (*plantæ*) of the anal prolegs; and which take on various forms, but are always directed forward so as to easily catch hold of the retaining membrane. In the yellow butterflies (as *Callydrias*, *Terias*, *Colias*), where the body of the chrysalis is so thrown back that mere projecting tubercles would not suffice, we find them transformed into actual hooks; while in some of the *succincti* they are little more than a thickening of the anterior margin of the subjoint. In all lepidopterous pupæ these remnants of the anal prolegs are more or less indicated, while in certain moths (*Pterophoridæ*), where the pupa is partly suspended, as in the *Nymphalidæ*, they are covered with long hooks similar to those at the tip of the cremaster.

Thirdly. We have what may be called the *sustentor ridges*, usually connected with the sustainers, and embracing them on the outside, and extending backward to the inside of the ventral cremastral ridges, and sometimes, as in *Paphia* and *Limenitis*, there forming quite a deep notch, which doubtless assists in catching hold of the larval skin in the efforts to attach the cremaster. These sustentor ridges are homologous with the limb of the anal prolegs, and the exposed edge with the posterior border of said limb. They vary much in form, and may be more or less obsolete.

Fourthly. Between them is what may be called the *rectal piece*, consisting of a piece more or less well marked and elevated, especially around the closed rectum.

It is principally by the leverage obtained by the hooking of the sustainers in the retaining membrane, which acts as a swinging fulcrum, that the chrysalis is prevented from falling after the cremaster is withdrawn from the larval skin. It is also principally by this same means that it is enabled to reach the silk with the cremastral hook-pad. Yet the rectal ligament plays a most important part, and in some species a more important part even, in my estimation, than the membrane itself. The tracheal ligaments, which, from a study of specimens plunged in alcohol when the larval skin was about half shed, I was at first inclined to believe important auxiliaries, are, I am now satisfied, of very little or no service in most cases. The rectal ligament is a constant physiological factor, and its importance cannot be ascertained by attempts to sever the membrane at the critical moment, because in such attempts the ligament is more or less drawn out beyond the power of the sphincter muscles in the chrysalis to control it.

Dissected immediately after suspension, and the subjoint of the larva will be found to be bathed, especially between the legs and around the rectum, in an abundance of translucent, membranous material. An hour or more after suspension the end of the forming chrysalis begins to separate from the larval skin, except at the tip of the cremaster. Gradually the skin of the legs and of the whole subjoint stretches, and with the stretching, the cremaster elongates, the rectal piece recedes more and more from the larval rectum, and the sustentor ridges diverge more and more from the cremaster, carrying with them, on the sustainers, a part of the soft membrane. If a larva be carefully dissected at this stage, the forming membrane may be raised with the point of a needle and stretched so as to show its connection with the rectal ligament; or it may be lifted entirely from the retainers, when, by its elasticity, it contracts and becomes more or less fully absorbed in the rectal ligament. It is at this stage that the strength of the latter may be fully tested, and if the chrysalis, flayed from the larval skin and freed from the retaining membrane, be grasped in the neighborhood of the rectum so as to supply the natural holding power of the sphincter muscles, the rectal ligament will sustain, as I have abundantly proved, at least ten or twelve times the weight of the chrysalis, while it will support, if held by the larval skin, several times the weight of the chrysalis before separating therefrom. In brief, the retaining membrane is that part of the inner larval skin surrounding the prolegs drawn down by the sustainers, and always intimately connected with and forming but a branch of the rectal ligament. When extended from its attachments, as when the chrysalis rises to the silk, this membrane dries, and in the cast off larval skin retains, more or less perfectly, the stretched form. If the corium of the larva was thick and strong, as in *Vanessa*, the dried membrane will be broad, with two indentations where it was held by the retainers; if the corium was more delicate, as in *Danais*, *Paphia*, or *Apatura*, the dried membrane is more forked, showing how the retainers have acted upon its elasticity. In every case, however, it shows, under the microscope, the longitudinal folds and creases incident to the stretching, and compared to the rectal ligament proper, it seems to lose importance as it is less needed; for the *succincti* will generally attach when it is severed or loosened from the retainers, while in *Apatura* (at least as exemplified in the North American species), which combines the peculiarities of both the *succincti* and *suspensi*,* it does not become specialized, and the chrysalis seems to rely almost entirely on the rectal ligament, assisted by the partial holding of the delicate larval skin, not only between what is left of the sustainers and the ventral posterior margin of the twelfth joint, but between the ventral sutures of this last and the preceding joint. And here I would remark, in conclusion, that the ventral borders of two or three of the joints preceding the subjoint are, in most chrysalids which I have studied, so hardened that the larval corium is actually grasped between them and the deep sutures made in contracting, or (what would be a more correct statement of the fact) it remains, adhering in these sutures after the outer skin is loosened, in the same way that the membrane remains on the sustainers. In some instances (especially in some species of *Papilio*) the posterior border of the twelfth joint is produced into a medial transverse ridge fully as prominent as that formed by the sustainers, which here are flattened and coalesce. So that the sutures of some of the terminal joints in the chrysalis do subserve the purpose ascribed to them by Réaumur, but in a somewhat different way.

* It is an interesting fact in this connection that Rösel, who has never had any superior as a delineator of insect larvæ, makes the Nymphalids in his figures all sus end to an elongate, conical piece of silk, apparently issuing from the anus, with the legs invariably free and in no instance hooked. It is evident, however, from his text, that he was not aware of the use of the anal plate, and since he speaks of the larvæ attaching themselves by the hind legs or extremity, it is equally evident that his figures do not correspond with the text; while the freedom of the legs in his figures, is, of course, an error.

* The larva of *Apatura* attaches horizontally, making the front pair of abdominal prolegs answer the purpose of the girth; but in the shedding of the skin this attachment is severed, and the forming chrysalis assumes the perpendicular position, and in the withdrawal and attachment of the cremaster, it acts as the true *suspensi*.

EXPERIMENTAL DETERMINATION OF THE VELOCITY OF LIGHT.

By ALBERT A. MICHELSON, Master, U. S. Navy.

[Read before the American Association.]

LET S, Fig. 1, be a slit through which light passes, falling on R, a mirror free to rotate about an axis at right angles to the plane of the paper; L, a lens of great focal length, upon which the light falls, which is reflected from R. Let M be a plane mirror, whose surface is perpendicular to the line R M, passing through the centers of R, *h*, and M, respectively. If L be so placed that an image of S is formed on the surface of M, then, this image acting as the object, its image will be formed at S, and will coincide point for point with S.

If, now, R be turned about the axis, so long as the light falls on the lens, an image of the slit will still be formed on the surface of the mirror, though on a different part, and as long as the returning light falls on the lens, an image of this image will be formed at S, notwithstanding the change of position of the first image at M. This result, namely, the production of a stationary image of an image in motion, is absolutely necessary in this method of experiment. It was first accomplished by Foucault, and in a manner differing apparently but little from the foregoing.

In this case, L, Fig. 2, served simply to form the image of S, at M; and M, the returning mirror, was spherical, the center coinciding with the axis of R. The lens, L, was placed as near as possible to R. The light forming the return image lasts, in this case, while the first image is sweeping over the face of the mirror, M. Hence, the greater the distance, R M, the larger must be the mirror, in order that the same quantity of light may be preserved, and its dimensions would soon become inordinate. The difficulty was partly met by Foucault, by using five concave reflectors instead of one; but even then the greatest distance he found it practicable to use was only 20 meters.

Returning to Fig. 1, suppose that R is in the principal focus of the lens, L; then, if the plane mirror, M, have the same diameter as the lens, the first or moving image will remain upon M as long as the axis of the pencil of light re-

mains on the lens, and *this will be the case no matter what the distance may be.*

When the rotation of the mirror, R, becomes sufficiently rapid, then the flashes of light which produce the second or stationary image become blended, so that the image appears to be continuous. But now it no longer coincides with the slit, but is deflected in the direction of the rotation, and through twice the angular distance described by the mirror, during the time required for light to travel twice the distance between the mirrors. This displacement is measured by its arc, or, rather, by its tangent. To make this as large as possible, the distance between the mirrors, the radius, or distance from the revolving mirror to the slit,

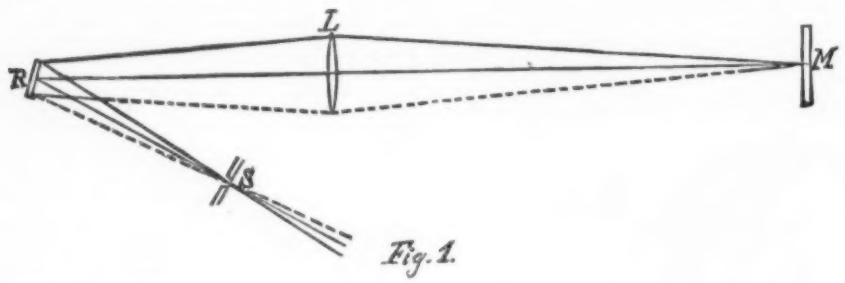


Fig. 1.

and the speed of rotation should be made as great as possible.

The second condition conflicts with the first, for the "radius" is the difference between the distances of principal focus and the conjugate focus for the distant mirror. The greater the "distance," therefore, the smaller will be the "radius." There are two ways of solving the difficulty: first, by using a lens of great focal length, and, secondly, by placing the revolving mirror within the principal focus of the lens. Both means were employed. The focal length of the lens was 150 feet, and the mirror was placed about 15 feet within the principal focus. A limit is soon reached, however, for the quantity of light received diminishes very rapidly as the revolving mirror approaches the lens.

The chief objection urged in reference to the experiments made by Foucault is that the deflection was too small to be measured with the required degree of accuracy. This deflection was but a fraction of a millimeter, and when it is added that the image is always more or less indistinct on account of atmospheric disturbances, as well as imperfections of lenses and mirrors, it may well be questioned whether the results could be relied upon within less than one per cent.

In the following experiments the distance between the mirrors was nearly 2,000 feet. The radius was about 30 feet, and the speed of the mirror was about 256 revolutions per second. The deflection exceeded 133 millimeters, being about 200 times that obtained by Foucault. If it were necessary it could be still further increased. This deflection was measured within three or four hundredths of a millimeter in each observation; and it is safe to say that the result, so far as it is affected by this measurement, is correct to within one ten-thousandth part.

The site selected for the experiments was a clear, almost level stretch along the north sea-wall of the Naval Academy. A frame building was erected at the western end of the line, a plan of which is represented in Fig. 3.

The building was 45 feet long and 14 feet wide, and raised so that the line of light was about 11 feet above the ground. A heliostat at H reflected the sun's rays through the slit at S to the revolving mirror, R, thence through a hole in the shutter, through the lens, and to the distant mirror. The interior of the building was painted black. In a room underneath the part, R, was the apparatus which supplied the air for turning the mirror.

The heliostat was kindly furnished by Dr. Woodward, of the Army Medical Museum, and was a modification of Foucault's form, designed by Keith. It was found to be easy of adjustment and quite accurate.

The light was reflected from the heliostat to a plane mirror, M, Fig. 3, so that the former need not be disturbed after being once adjusted.

The revolving mirror was made by Fauth & Co., of Washington. It consists of a cast-iron frame resting on three leveling screws, one of which was connected by cords to the table at S, Fig. 3, so that the mirror could be inclined forward or backward while making the observations. Two binding screws, terminating in hardened steel conical sockets, hold the revolving part. This consists of a steel axle, X Y, Fig. 5, the pivots being hardened, expanding into a ring at R, which holds the mirror, M. The latter was a disk of plane glass, made by Alvan Clark, about $1\frac{1}{4}$ inch in diameter and 0·2 inch thick. It was silvered on one side, the reflection taking place from the silvered side. A species of turbine wheel, T, is held on the axle by friction. This wheel has six openings for the escape of air; a section of one of them is represented in Fig. 6. The air entering on one side at O, Fig. 5, acquires a rotary motion in the box, B B, carrying the wheel with it, and this motion is assisted by the reaction of the air in escaping. The disk, C, serves the purpose of bringing the center of gravity in the axis of rotation. This was done, following Foucault's plan, by allowing the pivots to rest on two inclined planes of glass, allowing the arrangement to come to rest, and filing away the lowest part of the disk; then trying again, and so on, till it would rest in indifferent equilibrium. The part corresponding to C in Foucault's apparatus was furnished with three vertical screws, by moving which the axis of figure was brought into coincidence with the axis of rotation. This adjustment was very troublesome, and in this apparatus was found unnecessary. When the adjustment is perfect the apparatus revolves without giving any sound, and when this is attained the motion is regular and the speed great. A slight deviation causes a sound, due to the rattling of the pivots in the sockets, the speed is very much diminished, and the pivots commence to wear. In Foucault's apparatus oil was furnished to the pivots, through small holes running through the screws, by pressure of a column of mercury. In this apparatus it was found sufficient, at high speed, to touch the pivots occasionally with a drop of oil.

Fig. 7 is a view of the turbine, box, and supply tube, from above. The quantity of air entering could be regulated by a valve, to which was attached a cord leading to the table. The revolving mirror was mounted on a brick pier.

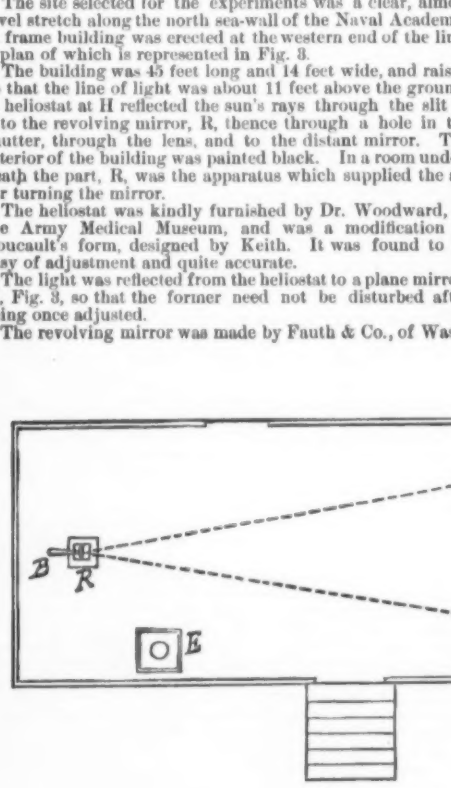


FIG. 3.

The apparatus for measuring the deflection was made by Grunow, of New York.

It consists of a screw, with divided circle. To the frame is attached an adjustable slit. On the screw travels a carriage which supports the eyepiece, which consists of an achromatic lens, having in its focus at the end of the tube a single vertical silk fiber.

Next the eye is a piece of plane glass, inclined at an angle of 45°. In measuring the deflection, the eyepiece is moved till the cross hair bisects the slit (with which it is nearly in the same plane), and the reading of the scale and divided circle gives the position. This is made once for all, unless the slit be altered in width or position. Then the eyepiece is moved till the cross hair bisects the deflected image of the slit; the reading of scale and circle are again taken, and the difference in readings gives the deflection. The screw has no lost motion, so that readings may be taken with the screw turned in either direction. This apparatus is mounted on a standard with rack and pinion, and the base furnished with leveling screws.

To regulate and measure the speed of rotation, a tuning fork, bearing on one prong a steel mirror, was employed. This was kept in vibration by a current of electricity from five gravity cells. The fork was so placed that the light from the revolving mirror was reflected to the piece of plane glass in the eyepiece, thence reflected into the eye. When fork and revolving mirror are both at rest, the eye sees an image of the revolving mirror. When the fork vibrates, this image is drawn out into a band of light. When the mirror commences to revolve, this band breaks up into a number of moving images of the mirror; and when, finally, the mirror makes as many turns as the fork makes vibrations, these images are reduced to one which is stationary. This is also the case when the number of turns is a submultiple. When it is a multiple, or a simple ratio, the only difference is that there will be more than one image.

Hence, to make the mirror execute a given number of turns, all that is necessary is to pull the cord attached to the valve, to the right or left, till the images of the revolving mirror come to rest.

The electric fork made about 128 vibrations per second. No dependence was placed upon this rate, however, but at each set of observations it is compared with a standard Ut_3 fork, the temperature being noted at the same time. In making the comparison the beats were counted for 60 seconds.

It is interesting to note that the electric fork, as long as it remained untouched and at the same temperature, did not change its rate more than 0·01 or 0·02 vibration per second.

Fig. 9 represents the table at which the observer sits. The light from the heliostat passes through the slit at S, goes to the revolving mirror, etc., and on its return forms an image of the slit at D, which is observed through the eyepiece. E represents the electric fork, bearing the steel mirror, M; K, the standard fork on its resonator.

The lens was made by Alvan Clark. It was 8 inches in diameter, focal length 150 feet, not achromatic. It was mounted in a wooden frame, placed on a support moving on a slide about 16 feet long, placed about 80 feet from the building. As the diameter of the lens was so small in comparison with its focal length, its want of achromatism was inappreciable. For the same reason the effect of "parallax" was too small to be noticed.

The stationary mirror was one of those used in taking photographs of the transit of Venus. It was about seven inches in diameter, mounted in a brass frame capable of adjustment in a vertical and a horizontal plane by screw motion. Being prismatic, it had to be silvered on the front surface. To facilitate adjustment, a small telescope furnished with cross hairs was attached to the mirror by a universal joint. The heavy frame was mounted on a brick pier, and the whole surrounded by a wooden case, to protect it from the sun.

The adjustment was effected as follows:

A theodolite was placed at about 100 feet in front of the mirror, and the latter was moved about, till the observer at the theodolite saw the image of his glass reflected in the center of the mirror. Then the telescope attached to the

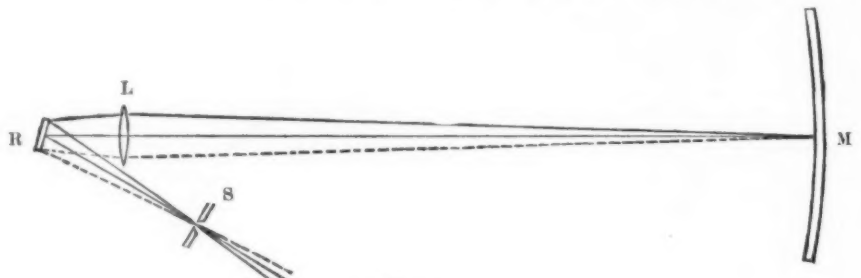


Fig. 2.

mirror was pointed at a mark on a piece of cardboard attached to the theodolite. Thus, the axis of the telescope was placed at right angles to the surface of the mirror. The theodolite was then moved to 1,000 feet, and, if found necessary, the adjustment repeated. Then the mirror was moved till its telescope pointed at the hole in the shutter of the building. The adjustment was completed by moving the mirror by signals, till the observer, looking through the hole in the shutter through a good spyglass, saw the image of the glass reflected centrally in the mirror.

Notwithstanding the wooden case about the pier the mirror would change its position between morning and evening, so that the last adjustment had to be repeated before every series of experiments.

Fig. 10 represents a plan of the lower floor of the building. E is a three horse power Lovegrove engine and boiler, resting on a stone foundation: B, a small Roots' blower; G, an automatic regulator. From this the air goes to a delivery pipe up through the floor to the turbine. The engine made about four turns per second, and the blower about fifteen. At this speed the pressure of the air was about half a pound per square inch.

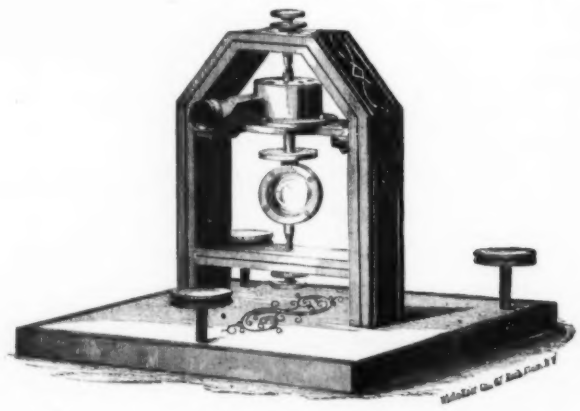


FIG. 4

The regulator, Fig. 11, consists of a strong bellows, supporting a weight of 370 pounds, partly counterpoised by 80 pounds, in order to keep the bellows from sagging. When the pressure of the air from the blower exceeds the weight, the bellows commences to rise, and in so doing closes the valve, V.

This arrangement was found in practice to be insufficient, and the following addition was made: A valve was placed at P, and the pipe was tapped a little farther on, and a rub-

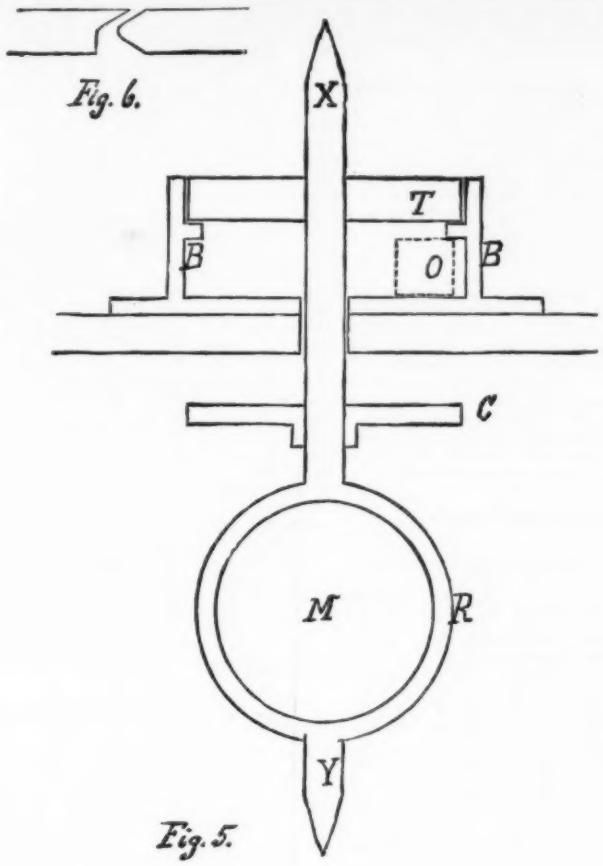


Fig. 5.

Fig. 6.

ber tube led to a water gauge, Fig. 12. The column of water in the smaller tube is depressed, and when it reaches the horizontal part of the tube, the slightest variation of pressure sends the column from one end to the other. This is checked by an assistant at the valve, so that the column of water is kept at nearly the same point, and the pressure thus rendered very nearly constant. The result was satisfactory, though not in the degree anticipated. It was possible to keep the mirror at a constant speed for three or four seconds at a time, and this was sufficient for an observation. Still it would have been more convenient to have kept it so for a longer time. The test of uniformity was, however, very sensitive, as a change of speed of 0·02 of a revolution per second could be detected.

It was found that the only time during the day when the atmosphere was sufficiently quiet to get a distinct image was during the hour after sunrise or during the hour before sunset. At other times the image was "boiling," so as not to be recognizable. In one experiment the electric light was used at night, but the image was no more distinct than at sunset, and the light was unsteady.

The method followed in experiment was as follows: The fire was started half an hour before, and by the time everything was ready the gauge would show 40 or 50 pounds of steam. The mirror was adjusted by signals as before described. The heliostat was placed and adjusted. The revolving mirror was adjusted by being moved about till the light returned to it from the distant mirror The axis of the revolving mirror was also inclined to the right or the left, so that the direct reflection of light from the slit fell above or below the eyepiece, as otherwise this light would overpower that from the reflection from the distant mirror, etc., which forms the image to be observed. This inclination of the axis of rotation introduces a small error, which is duly allowed for in the calculations.

The distance between the front face of mirror and the cross hair of the eyepiece was then measured, by stretching from one to the other a steel tape, making the drop of the catenary about an inch—when the error on account of the curve, and that due to the stretching of the tape, just counterbalanced each other.

The position of the slit, if not determined before, was then found as before described. The electric fork was then started, the temperature noted, and the beats between it and the standard fork counted for 60 seconds. This was repeated two or three times before every set of observations.

The eyepiece of the micrometer was then set approximately, and the revolving mirror started. If the image did not appear, the mirror was inclined forward or backward till it came in sight.

The cord connected with the valve was pulled right or left, till the images of the revolving mirror, represented by the two round spots to the left of the cross hair, came to rest. Then the screw was turned till the cross hair bisected the deflected image of the slit. This was repeated till ten observations were taken, when the mirror was stopped, temperature noted, and beats counted. This was called a set of observations. Usually five such sets were taken morning and evening.

The steel tape used was one of Chesterman's, 100 feet long. It was carefully compared with the copy of the standard yard made by Wurdemann, by a comparator. The result showed that the error of the tape was 0·006 foot. The true length was 100·006 feet.

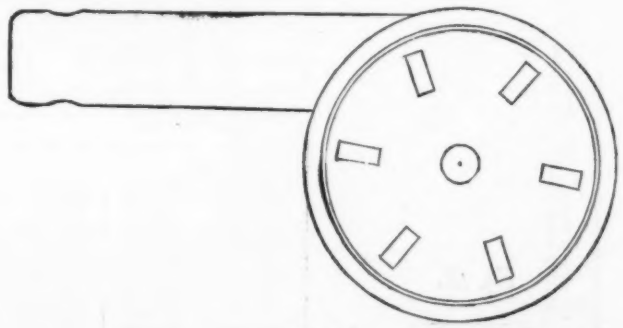


Fig. 7.

The micrometer was also compared with the standard yard and the standard meter, the first giving for the value of one scale division, 0·99650 mm.
and the second, 0·99642 "

Mean, 0·99646 mm.

One turn of the screw was found equal to 1·00009 divisions. Hence the value of one turn was 0·99655 millimeter.

The distance between the pier for the revolving mirror and the stationary mirror was measured by means of the steel tape. Square lead weights were placed along the line, and measurements taken from one to the other, the tape resting on the ground and stretched by a force of 10 pounds. The measurements, five in all, were all made at about 62° F. The results are:

	1985·13
	1985·17
	1984·93
	1985·09
	1985·09
Mean,	1985·089

Fig. 8.

Correction for stretch of tape	0·33
" " length of tape	0·12
Distance from pier to revolving mirror	0·70
Total correction	1·15
	1985·08
True distance	1986·23

The rate of vibration of the standard fork armed with a tip of copper foil was found by allowing it to trace its record on the lampblacked cylinder of a Schultz's chronoscope. The time was given either by a sidereal break-circuit chronometer or by a mean time clock. In the former case the break circuit worked a relay which interrupted the current from three Grove cells. In the latter, the circuit was broken by the pendulum. The spark from the secondary coil of a Ruhmkorff was delivered from a wire near the tip of the fork. The rate of the chronometer, the record of which was kept at the Observatory, was very regular. It was found, from observations of transits of stars during the week, to be +1·3 seconds per day, which is the same as the recorded rate.

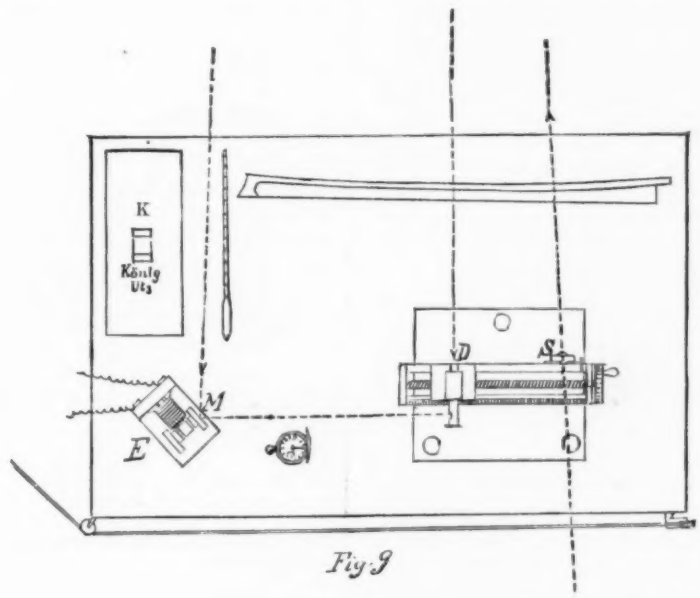


Fig. 9.

The correction for temperature was found by Professor Mayer to be +0·012 v.s. for a diminution of one degree Fahr.

My own result was +0·0125 v.s.
Adopted +0·012.

The following is the table of results:

	256·069
	256·089
	256·077
	256·012
	256·087
	256·074
	256·061
	256·100
	256·084
	256 066
Mean,	256·073

In one of these observations I counted the beats between this fork and another, first while the former was tracing its record, and then when it was free and in position as for use. The difference, if any, was less than 0·01 v.s.

As the result obtained depends directly on the rate of vibration of the fork, I was not willing to trust entirely to my own work, and asked Professor Mayer to make a determination.

He kindly offered to make it together with myself. Accordingly, I went to the Hoboken Institute, and a series of ten determinations were made under the following conditions:

The fork was wedged into a wooden support, and the tip allowed to rest on lampblacked paper wound about a metal cylinder, which was turned by hand. Break-circuit clock was used, the rate of which was ascertained by comparison

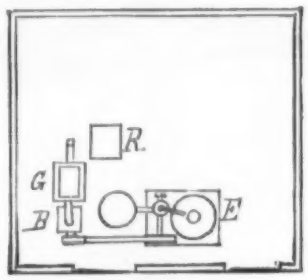


FIG. 10.

with the Western Union time-ball. The spark from the Ruhmkorff passed from the tip of metal attached to the fork, piercing the paper. Size of the spark was regulated by resistances.

Table of results was as follows:

256·072
256·126
256·091
256·108
256·068
256·090
256·112
256·124
256·080
256·070
Mean, 256·094

The effect of scrape was sought for again, and found to be 0·004 v.s.

The effect of the support, however, was greater, both combined being —0·026 v.s.

Making this correction, the result becomes:

	256·068
Former result,	256·072
Mean,	256·070 vibrations per second, at 65° Fahr.

The formulæ employed in the calculations are:

$$(1) \ldots\ldots \tan\phi = \frac{d_1}{r}$$

$$(2) \ldots\ldots\ldots V = \frac{2592000'' \times D \times n}{\varphi''}$$

Where ϕ = angle of deflection.
d_1 = displacement, or $r \cdot \tan\phi$.
r = radius of measurement.
D = twice the distance between mirrors.
n = number of revolutions per second.
α = inclination of plane of rotation.
V = velocity.

D and r are expressed in feet, and d_1 in millimeters. Substituting for d_1 its value,

$$d \times 0{\cdot}99655 \times \sec\alpha,$$

where d_1 is the displacement in turns of screw, and log sec α = 0·00008, we have, reducing to kilometers:

$$(3) \ldots\ldots \tan\phi = c_1 \frac{d}{r} \qquad \log\ c_1 = 0{\cdot}51457$$

$$(4) \ldots\ldots\ldots V = c \frac{n}{\varphi} \qquad \log\ c = 0{\cdot}49670$$

In the calculations the effect of temperature on the screw, scale, and tape used in finding ρ was neglected. It can be applied to the final result for the mean temperature, which was 75·6° Fahr.

Correction for tan ϕ is —0·000003 ×13·1 = —0.0004.
Correction for V is +12 kilometers.

The direction of rotation was right-handed. To eliminate any possible error on this account, the mirror in eight of the later observations was inverted, thus making the rotation left-handed, and the deflection measured to the left. The results were the same as before, within the limits of error.

To eliminate errors due to a regular variation in speed during every revolution, if any such could exist, the position of the frame was changed in several experiments. The results were the same as before.

To test the question as to whether the vortex of air about the mirror had any effect on the deflection, the speed was lowered to 192, 128, 96, and 64 turns per second. If the vortex had any effect, it should have decreased with the lower speed, but no such effect could be detected.

Finally, to test if there were any bias in making the observations, the readings in several sets were taken by another, and the results written down without divulging them. The separate readings, as will be shown in the following specimen, were as consistent as when made by myself, and the final results agree with those of other observations:

SPECIMEN OF OBSERVATIONS.

June 17th, Sunset. Image good (best in column 4).

	(1)	(2)	(3)	(4)	(5)
	112·81	112·80	112·83	112·74	112·79
	112·81	112·81	112·81	112·76	112·78
	112·79	112·78	112·78	112·74	112·74
	112·80	112·75	112·74	112·76	112·74
	112·79	112·77	112·74	112·76	112·77
	112·82	112·79	112·72	112·78	112·81
	112·76	112·73	112·76	112·78	112·77
	112·83	112·78	112·81	112·79	112·75
	112·78	112·79	112·74	112·83	112·82
	112·82	112·73	112·76	112·78	112·82
Means =	112·801	112·773	112·769	112·772	112·779
Zero =	0·260	0·260	0·260	0·260	0·260
d =	112·541	112·513	112·509	112·512	112·519

Temp. = 77°, B = +1·500, cor. = —0·144, diff. = +1·356,
added to 256·070 = 257·426 = n
28·155 = r

Results from the above.

299,660	299,740	299,740	299,740	299,720

DATA FOR WORKING OUT OBSERVATIONS.

Ut_3 fork makes 256·070 vibr. per sec. at 65° Fahr.
D = 3,972·46 feet.
tan α = tangent of inclination of plane of rotation = 0·02.
c_1 log = 0·51457.
c log = 0·49670.
d = deflection as read from micrometer.
r = radius.
φ = angle of deflection.
n = number of revolutions per second.
V = velocity of light in kilometers.
B = number of beats per second between electric Ut_3 fork and standard Ut_3 fork. Electric fork makes $\frac{1}{2}$ (256·07 + B + cor.) vibr. per second, and n is a multiple submultiple or simple ratio of this.
Cor. = correction for temperature of standard,
= —0·012 v.s. per degree Fahr.

The numbers in column two of the following table are thus interpreted:

3 = Good.
2 = Fair.
1 = Poor.

These numbers do not, however, show the relative weights of observations.

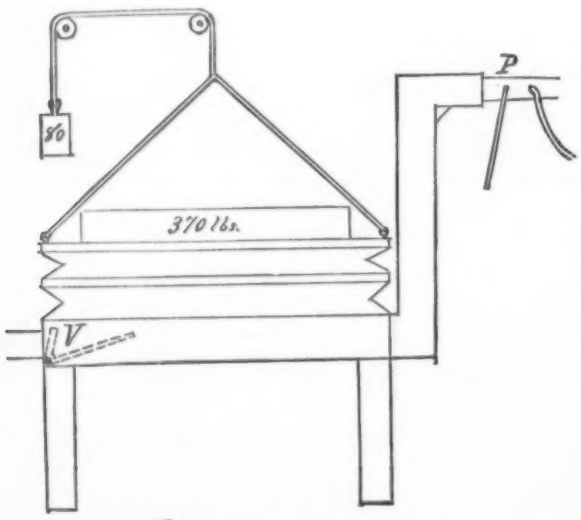


Fig. 11.

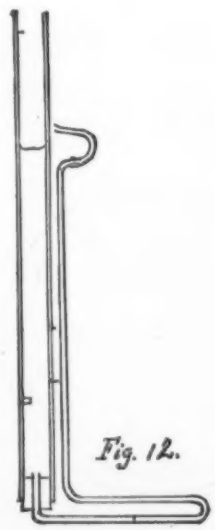


Fig. 12.

DATE.		Distinctness of image.	Temperature, Fahr.	Displacement of image per micrometer.	Radius of measurement in feet.	Number of revolutions per second.	Velocity of light in air in kilometers.	REMARKS.
June	5	3	76	114·55	28·670	257·36	299,710	Electric light.
"	7	2	72	114·56	28·653	257·52	299,600	P.M. Frame inclined at various angles.
"	7	2	72	114·50	28 645	257·52	299,760	
"	7	2	72	85·84	28·645	193·14	299,880	
"	7	3	72	85·89	28·648	193·14	299,740	" "
"	7	2	72	114·53	28 648	257 52	299,710	" "
"	9	3	83	114·47	28·656	257·39	299,810	" "
"	9	3	83	114·46	28 656	257·39	299,840	" "
"	9	3	83	114·47	28·660	257·39	299,840	" "
"	9	3	83	114·50	28 658	257·39	299,740	" "
"	9	2	83	114·53	28·676	257·39	299,860	" "
"	10	2	90	114·52	28·683	257·29	299,840	" "
"	10	2	90	114·54	28·683	257·29	299,790	" "
"	12	2	71	114·74	28·688	257·45	299,510	A.M.
"	12	2	71	114·70	28·688	257·45	299,620	"
"	12	1	71	114·68	28·688	257·45	299,670	"
"	13	3	72	112·56	28·170	257·49	299,860	P.M.
"	13	3	72	112·56	28·170	257·49	299,860	"
"	13	2	72	112·57	28·170	257·49	299,820	"
"	13	3	79	112·56	28·176	257·42	299,820	"
"	13	3	79	112·56	28·176	257·42	299,820	"
"	13	3	79	112·57	28·176	257·42	299,800	"
"	13	3	79	112·56	28·176	257·42	299,820	"
"	13	3	79	112·57	28·176	257·42	299,800	"
"	13	3	79	113·15	28·150	258·70	299,740	" Set micr. and counted oscillations of image of mirror.
"	13	3	79	111 88	28·150	255·69	299,660	
"	14	1	64	112·57	28·150	257·58	299,710	A.M.
"	14	1	64	112·57	28·150	257 60	299,740	"
"	14	1	65	112·55	28·150	257 59	299,760	"
"	14	1	66	112·57	28·150	257·57	299,700	"
"	14	1	67	112·57	28·150	257·56	299,690	"
"	14	1	84	112·52	28·157	257·36	299,650	P.M. Readings
"	14	1	85	112·50	28·157	257·33	299,670	" taken by Lt.
"	14	1	84	112·46	28·157	257·32	299,700	" Nazro.
"	14	1	84	112·47	28·157	257·32	299,740	P.M.
"	14	1	84	112·49	28·157	257 32	299,690	"
"	17	2	62	112·59	28·147	257·62	299,660	A.M.
"	17	2	63	112·58	28 147	257·59	299,650	"
"	17	1	64	112 59	28·147	257·58	299,620	"
"	17	3	77	112·54	28·155	257·43	299,660	P.M. Readings
"	17	3	77	112·51	28·155	257 43	299,740	" taken by Mr.
"	17	3	77	112·51	28·155	257·43	299,740	" Clason.
"	17	3	77	112·51	28·155	257·43	299,740	" "
"	17	3	77	112 52	28·155	257·43	299,720	" "
"	18	1	58	112 64	28·148	257·65	299,580	A.M.
"	18	1	58	112·64	28·148	257·65	299,580	"
"	18	1	59	112 66	28 148	257·62	299,480	"
"	18	2	75	112·52	28 156	257·43	299,720	P.M.
"	18	2	75	112·48	28·156	257 43	299,830	"
"	18	2	75	112·49	28·156	257·43	299,810	"
"	20	3	60	112·67	28·170	257·65	299,740	A.M.
"	20	3	61	112·65	28·170	257·63	299,770	"
"	20	2	62	112·67	28·170	257·62	299,710	"
"	20	2	63	112·66	28·170	257·61	299,730	"
"	20	2	78	133·21	33·343	257·36	299,740	P.M.
"	20	2	79	133·23	33·343	257·40	299,740	"
"	20	2	80	133·22	33·343	257·39	299,750	"
"	20	2	79	133·24	33·343	257·39	299,740	"
"	20	2	79	133·22	33·343	257·38	299,740	"
"	20	2	79	133·22	33·343	257·38	299,740	"
"	21	2	61	133·29	33·330	257·65	299,790	A.M.
"	21	2	62	133·31	33·330	257·64	299,710	"
"	21	2	63	133·31	33·330	257·63	299,710	"
"	21	2	64	133 30	33·330	257·61	299,720	"
"	21	2	65	133·30	33·330	257·60	299,700	"
"	21	3	80	133·21	33·328	257·42	299,670	P.M.
"	21	3	81	133·19	33·328	257·38	299,660	"
"	21	3	82	133·20	33·3: 8	257·37	299,640	"
"	21	3	82	133·20	33·328	257 38	299,650	"
"	21	3	81	133·19	33·328	257·38	299,660	"
"	23	3	89	133·16	33·343	257·32	299,810	"
"	23	3	89	133·15	33·343	257·33	299,820	"
"	23	3	90	133·17	33·343	257·32	299,790	"
"	23	3	90	133·16	33·343	257·30	299,760	"
"	23	3	90	133·16	33·343	257·29	299,780	"
"	24	3	72	133·20	33·317	257·50	299,620	A.M.
"	24	3	73	133·17	33·317	257 49	299,740	"
"	24	3	74	133·16	33·317	257·48	299,750	"
"	24	3	75	133·16	33·317	257·47	299,750	"
"	24	3	76	133·18	33·317	257·45	299,680	"
"	26	2	86	133·15	33·337	257·33	299,790	P.M.
"	26	2	86	133·17	33·337	257·33	299,740	"
"	27	3	73	133·22	33·326	257·46	299,680	A.M.
"	27	3	74	133·20	33·326	257·44	299,710	"
"	27	3	75	133·21	33·326	257·43	299,660	"
"	27	3	75	133·19	33·326	257·42	299,710	"
"	27	3	76	133·20	33·326	257·42	299,690	"
"	27	3	76	133·19	33·326	257·42	299,710	"
"	30	2	85	99·68	33·272	193·00	299,770	P.M. Mirror inverted.
"	30	2	86	99·67	33·272	193·00	299,800	" "
"	30	2	86	99·66	33·272	193·00	299,820	" "
"	30	2	86	99·66	33·272	193 00	299,820	" "
July	1	2	83	132·98	33·280	257 35	299,710	" "
"	1	2	84	133·00	33·280	257·34	299,640	" "
"	1	2	86	133·01	33·309	257·28	299,810	" "
"	1	2	86	133 00	33·309	257·28	299,840	" "
"	2	3	86	99·45	33·203	192 95	299,780	" Mirror erect.
"	2	3	86	66·34	33·203	128·63	299,580	" "
"	2	3	86	47 96	33·203	96·48	299,560	" "
"	2	3	85	33·17	33·203	64·32	299,610	" "

RESULTS OF OBSERVATIONS.

299,710	299,860	299,820	299,690	299,740
299,600	299,840	299,800	299,650	299,740
299,760	299,790	299,820	299,670	299,740
299,880	299,510	299,800	299,740	299,720
299,740	299,620	299,740	299,740	299,580
299,710	299,670	299,660	299,690	299,580
299,810	299 860	299,710	299,660	299,480
299,840	299,860	299,740	299,650	299,720
299,840	299,830	299,760	299,620	299,830
299,740	299,820	299,700	299,660	299,810

299,740	299,790	299,810	299,790	299,820
299,770	299,710	299,830	299,740	299,820
299,710	299,710	299,790	299,680	299,710
299,730	299,720	299,760	299,710	299,640
299,740	299,700	299,780	299,660	299,810
299,740	299,670	299,620	299,710	299,840
299,750	299,660	299,740	299,690	299,780
299,710	299,640	299,750	299,710	299,580
299,740	299,650	299,750	299,770	299,560
299,740	299,660	299,680	299,800	299,610

Mean result..... 299,728
Cor. for temp..... +12

Vel. of light in air.... 299,740
Cor. for vacuum..... +88

Vel. of light in vacuo = 299,828 kilometers per second.

MYTHOLOGIC PHILOSOPHY.

Vice-Presidential Address of Prof. J. W. POWELL, of Washington, Vice-President Section B, American Association for the Advancement of Science, Saratoga Meeting, August, 1879.

I. THE GENESIS OF PHILOSOPHY.

THE wonders of the course of nature have ever challenged attention. In savagery, in barbarism, and in civilization alike, the mind of man has sought the explanation of things.

The movements of the heavenly bodies, the change of seasons, the succession of night and day, the powers of the air, majestic mountains, ever-flowing rivers, perennial springs, the flight of birds, the gliding of serpents, the growth of trees, the blooming of flowers, the forms of storm-carved rocks, the mysteries of life and death, the institutions of society—many are the things to be explained.

The yearning to know is universal.

How and *why* are everlasting interrogatories profoundly instinct in humanity.

In the evolution of the human mind, the instinct of cosmic interrogation follows hard upon the instinct of self-preservation.

In all the operations of nature, man's weal and woe is involved. A cold wave sweeps from the north, rivers and lakes are frozen, forests are buried under snows, and the fierce winds almost congeal the life fluids of man himself, and man's sources of supply under the rocks of water. At another time the heavens are as brass, and the clouds come and go with mockery of unfulfilled promises of rain, the fierce midsummer sun pours its beams upon the sands, and scorching blasts heated in the furnace of the desert sear the vegetation, and the fruits, which in more congenial seasons are subsistence and luxury, shrivel before the eyes of famishing men. A river rages and destroys the adjacent valley with its flood. A mountain bursts forth with its rivers of hell, the land is buried, and the people are swept away.

Lightning shivers a tree and rends a skull.

The silent, unseen powers of nature too are at work bringing pain or joy, health or sickness, life or death to mankind. In like manner, man's welfare is involved in all the institutions of society.

How and *why* are the questions asked about all these things—questions springing from the deepest instinct of self-preservation.

In all stages of savage, barbaric, and civilized inquiry, every question has found an answer, every *how* has had its *thus*, every *why* its *because*. The sum of the answers to the questions raised by any people, constitute its philosophy; hence all people have had philosophies consisting of their accepted explanation of things. Such a philosophy must necessarily result from the primary instincts developed in man in the early progress of his differentiation from the beast. This I postulate; if demonstration is necessary, demonstration is at hand.

Not only has every people a philosophy, but every stage of culture is characterized by its stage of philosophy.

Philosophy has been unfolded with the evolution of the human understanding. The history of philosophy is the history of human opinions from the earlier to the later days—from the lower to the higher culture.

In the production of a philosophy phenomena must be discerned, phenomena must be discriminated, phenomena must be classified. Discernment, discrimination, and classification are the processes by which a philosophy is developed. In studying the philosophy of a people at any stage of culture, to understand what such a people entertain as the sum of their knowledge, it is necessary that we should understand what phenomena they saw, heard, felt—discerned; what discriminations they made, and what resemblances they seized upon as a basis for the classification on which their explanations rested. A philosophy will be higher in the scale, nearer the truth, as the discernment is wider, the discriminations nicer, and the classification better.

The sense of the savage is dull compared with the sense of the civilized man. There is a myth current in civilization to the effect that the barbarian has highly developed perceptive faculties. It has no more foundation than the myth of the wisdom of the owl. A savage sees but few sights, hears but few sounds, tastes but few flavors, smells but few odors, his whole sensuous life is narrow and blunt, and his facts, that are made up of the combination of sensuous impressions, are few.

In comparison the civilized man has his vision extended away toward the infinitesimal and away toward the infinite; his perception of sound is multiplied to the comprehension of rapturous symphonies; his perception of taste is increased to the enjoyment of delicious viands; his perception of smell is developed to the appreciation of most exquisite perfumes; and the facts that are made up of his combination of sensuous impressions are multiplied beyond enumeration. The stages of discernment, from the lowest savage to the highest civilized man, constitute a series, the end of which is far from the beginning.

If the discernment of the savage is little, his discrimination is less. All his sensuous perceptions are confused, but the confusion of confusion is that universal habit of savagery—the confusion of the objective with the subjective, so that the savage sees, hears, tastes, smells, feels the imaginings of his own mind. Subjectively determined sensuous processes are diseases in civilization, but normal functional methods in savagery.

The savage philosopher classifies by obvious resemblances—analogic characters. The civilized philosopher classifies by essential affinities—homologic characteristics; and the progress of philosophy is marked by changes from analogic categories to homologic categories.

II. TWO GRAND STAGES OF PHILOSOPHY.

There are two grand stages of philosophy—the mythologic and the scientific. In the first, all phenomena are explained by analogies derived from subjective human experiences; in the latter, phenomena are explained as orderly successions of events.

In sublime egotism man first interprets the cosmos as an extension of himself; he classifies the phenomena of the outer world by their analogies with subjective phenomena; his measure of distance is his own pace, his measure of time his own sleep, for he says, "It is a thousand paces to the great rock," or, "It is a thousand sleeps to the great feast." Noises are voices, powers are hands, movements are made afoot. By subjective examination discovering in himself will and design, and by inductive reason discovering will and design in his fellow men and in animals, he extends the induction to all the cosmos, and there discovers in all things will and design. All phenomena are supposed to be the acts of some one, and that some one having will and purpose.

In mythologic philosophy, the phenomena of the outer physical world are supposed to be the acts of living, willing, designing personages. The simple are compared with and explained by the complex.

In scientific philosophy, phenomena are supposed to be children of antecedent phenomena, and so far as science goes with its explanation, they are thus interpreted.

Man with the subjective phenomena gathered about him is studied from an objective point of view, and the phenomena of subjective life are relegated to the categories established in the classification of the phenomena of the outer world; thus the complex is studied by resolving it into its simple constituents.

Some examples of the philosophic methods belonging to widely separated grades of culture may serve to make my statements clearer.

WIND.

The Ute philosopher discerns that men and animals breathe. He recognizes vaguely the phenomena of the wind and discovers its resemblance to breath, and explains the winds by relegating them to the class of breathings.

He declares that there is a monster beast in the north that breathes the winter winds, and another in the south, and another in the east, and another in the west. The facts relating to winds are but partially discerned; the philosopher has not yet discovered that there is an earth surrounding atmosphere. He fails also in making the proper discriminations.

His relegation of the winds to the class of breathings is analogic, but not homologic. The basis of his philosophy is personality, and hence he has four wind gods.

The philosopher of the ancient Northland discovered that he could cool his brow with a fan or kindle a flame or sweep away the dust with the wafted air. The winds also cooled his brow, the winds also swept away the dust and kindled the fire into a great conflagration, and when the wind blew he said, "Somebody is fanning the waters of the fiord," or, "Somebody is fanning the evergreen forests," and he relegated the winds to the class of fannings, and he said, "The god Hraesvelger, clothed with eagle plumes, is spreading his wings for flight, and the winds rise from under them."

The early Greek philosopher discovered that air may be imprisoned in vessels or move in the ventilation of caves, and he recognized wind as something more than breath, something more than fanning, something that can be gathered up and scattered abroad, and so when the winds blew he said, "The sacks have been untied," or, "The caves have been opened."

The philosopher of civilization has discovered that breath, the fan wafted breeze, the air confined in vessels, the air moving in ventilation, that these are all parts of the great body of air which surrounds the earth, all in motion, swung by the revolving earth, heated at the tropics, cooled at the poles, and thus turned into counter currents and again deflected by a thousand geographic features, so that the winds sweep across valleys, eddy among mountain crags, or waft the spray from the crested billows of the sea, all in obedience to cosmic laws.

The facts discerned are many, the discriminations made are nice, and the classifications based on true homologies, and we have the science of meteorology, which exhibits an orderly succession of events even in the fickle winds.

SUN AND MOON.

The Ute philosopher declares the sun to be a living personage, and explains his passage across the heavens along an appointed way by giving an account of a fierce personal conflict between Ta-vi, the sun god, and Ta-wats, one of the supreme gods of his mythology.

In that long ago, the time to which all mythology refers, the sun roamed the earth at will. When he came too near with his fierce heat the people were scorched, and when he hid away in his cave for a long time, too idle to come forth, the night was long and the earth cold Once upon a time Ta-wats, the hare-god, was sitting with his family by the camp fire in the solemn woods anxiously waiting for the return of Ta-vi, the wayward sun-god. Wearied with long watching the hare-god fell asleep, and the sun-god came so near that he scorched the naked shoulder of Ta-wats. Foreseeing the vengeance which would be thus provoked, he fled back to his cave beneath the earth. Ta-wats awoke in great anger, and speedily determined to go and fight the sun-god.

After a long journey of many adventures the hare-god came to the brink of the earth, and there watched long and patiently, till at last the sun-god coming out, he shot an arrow at his face, but the fierce heat consumed the arrow ere it had finished its intended course; then another arrow was sped, but that also was consumed, and another, and still another, till only one remained in his quiver, but this was the magical arrow that had never failed its mark. Ta-wats, holding it in his hand, lifted the barb to his eye, and baptized it in a divine tear; then the arrow was sped and struck the sun-god full in the face, and the sun was shivered into a thousand fragments, which fell to the earth, causing a general conflagration.

Then Ta-wats, the hare-god, fled before the destruction he had wrought, and as he fled, the burning earth consumed his feet, consumed his legs, consumed his body, consumed his hands and his arms; all were consumed but the head alone, which bowled across valleys and over mountains, fleeing destruction from the burning earth, until at last, swollen with heat, the eyes of the god burst and the tears gushed forth in a flood, which spread over the earth and extinguished the fire.

The sun-god was now conquered, and he appeared before a council of the gods to await sentence. In that long council was established the days and the nights, the seasons and the years, with the length thereof, and the sun was condemned to travel across the firmament by the same trail day after day till the end of time.

In the same philosophy we learn that in that ancient time a council of the gods was held to consider the propriety of making a moon, and at last the task was given to Whip-poor-will, a god of the night, and a frog yielded himself a willing sacrifice for this purpose, and the Whip-poor-will, by incantations and other magical means, transformed the frog into the new moon.

The truth of this origin of the moon is made evident to our very senses, for do we not see the frog riding the moon at night? And the moon is cold, because the frog from which it was made was cold.

The philosopher of Oraibi tells us that, when the people ascended by means of the magical tree which constituted the ladder from the lower world to this, they found the firmament—the ceiling of this world low down upon the earth—the floor of this world. Machito, one of their gods, raised the firmament on his shoulders to where it is now seen. Still the world was dark, as there was no sun, no moon, and no stars. So the people murmured because of the darkness and the cold. Machito said, "Bring me seven maidens," and they brought him seven maidens; and he said, "Bring me seven baskets of cotton bolls, and they brought him seven baskets of cotton bolls;" and he taught the seven maidens to weave a magical fabric from the cotton, and when they had finished it he held it aloft, and the breeze carried it away toward the firmament, and in the twinkling of an eye it was transformed into a beautiful full-orbed moon, and the same breeze caught the remnants of flocculent cotton which the maidens had scattered during their work, and carried them aloft, and they were transformed into bright stars. But still it was cold, and the people murmured again, and Machito said, "Bring me seven buffalo robes," and they brought him seven buffalo robes, and from the densely matted hair of the robes he wove another wonderful fabric, which the storm carried away into the sky, and it was transformed into the full-orbed sun.

Then Machito appointed times and seasons and ways for the heavenly bodies, and the gods of the firmament have obeyed the injunctions of Machito from the day of their creation to the present.

The Norse philosopher tells us that Night and Day each has a horse and a car, and they drive successively one after the other around the world in twenty-four hours.

Night rides first with her steed, named Dew-hair, and every morning as he ends his course he bedews the earth with foam from his bit. The steed driven by Day is Shining-hair.

All the sky and earth glisten with the light of his mane.

Jarnved, the great iron-wood forest lying to the east of Midgard, is the abode of a race of witches. One monster witch is the mother of many sons in the form of wolves, two of which are Skol and Hate. Skol is the wolf that would devour the maiden Sun, and she daily flies from the maw of the terrible beast, and the moon-man flies from the wolf Hate.

The philosopher of Samos tells us that the earth is surrounded by hollow crystalline spheres set one within another, and all revolving at different rates from east to west about the earth, and that the sun is set in one of these spheres and the moon in another.

The philosopher of civilization tells us that the sun is an incandescent globe, one of the millions afloat in space.

About this globe the planets revolve, and the sun and planets and moons were formed from nebulous matter by the gradual segregation of their particles, controlled by the laws of gravity, motion, and affinity.

The sun, traveling by an appointed way across the heavens, with the never-ending succession of day and night, and the ever-recurring train of seasons, is one of the subjects of every philosophy. Among all peoples, in all times, there is an explanation of these phenomena, but in the lowest stage, away down in savagery, how few the facts discerned, how vague the discriminations made, how superficial the resemblances by which the phenomena are classified!

In this stage of culture, all the daily and monthly and yearly phenomena, which come as the direct result of the movements of the heavenly bodies, are interpreted as the doings of some one, some good acts. In civilization, the philosopher presents us the science of astronomy, with all its accumulated facts of magnitude, and weights, and orbits, and distances, and velocities, with all the nice discriminations of absolute, relative, and apparent motions, and all these facts he is endeavoring to classify in homologic categories, and the evolutions and revolutions of the heavenly bodies are explained as an orderly succession of events.

RAIN.

The Shoshoni philosopher believes the domed firmament to be ice, and surely it is the very color of ice, and he believes further that a monster serpent-god coils his huge back to the firmament, and with his scales abrades its face and causes the ice-dust to fall upon the earth. In the winter time it falls as snow, but in the summer time it melts and falls as rain, and the Shoshoni philosopher actually sees the serpent of the storm in the rainbow of many colors.

The Oraibi philosopher who lives in a pueblo is acquainted with architecture, and so his world is seven-storied. There is a world below, and five worlds above this one. Muingwa, the rain-god who lives in the world immediately above, dips his great brush, made of feathers of the birds of the heavens, into the lakes of the skies, and sprinkles the earth with refreshing rain for the irrigation of the crops tilled by these curious Indians who live on the cliffs of Arizona. In winter Muingwa crushes the ice of the lakes of the heavens, and scatters it over the earth, when we have a snow-fall.

The Hindoo philosopher says that the lightning bearded Indra breaks the vessels that hold the waters of the skies with his thunderbolts, and the rains descend to irrigate the earth.

The philosopher of civilization expounds to us the methods by which the waters are evaporated from the land and the surface of the sea, and carried away by the winds and gathered into clouds, to be discharged again upon the earth, keeping up for ever that wonderful circulation of water from the heavens to the earth and from the earth to the heavens, that orderly succession of events in which the waters travel by river, by sea, and by cloud.

RAINBOW.

In Shoshoni, the rainbow is a beautiful serpent that abrades the firmament of ice to give us snow and rain.

In Norse, the rainbow is the bridge Bifrost, spanning the space between heaven and earth.

In the Iliad, the rainbow is the goddess Iris, the messenger of the King of Olympus.

In Hebrew, the rainbow is the witness to a covenant.

In science, the rainbow is an analysis of white light into its constituent colors by the refraction of rain drops.

FALLING STARS.

In Ute, falling stars are the excrements of dirty little star-gods.

In science—well, I do not know what falling stars are in science. I think they are cinders from the furnaces where the worlds are forged. You may call this mythologic or scientific, as you please.

MIGRATION OF BIRDS.

The Algonkin philosopher explains the migration of birds by relating the myth of the combat between Ka-bi-no-ke and Shingapis, the prototype or progenitor of the water-hen, one of their animal gods. A fierce battle raged between Ka-bi-no-ke and Shingapis, but the latter could not be conquered.

All the birds were driven from the land but Shingapis, and then was it established that, whenever in the future Wintermaker should come with his cold winds, fierce snows, and frozen waters, all the birds should leave for the south except Shingapis and his friends. So the birds that spend their winters north are called by the Algonkin philosophers "the friends of Shingapis."

In contrast to this explanation of the flight of birds may be placed the explanation of the modern evolutionist, who says that the birds migrate in quest of abundance of food and a genial climate, guided by an instinct of migration which is a cumulation of inherited memories.

DIVERSITY OF LANGUAGES.

The Kaibabit philosopher accounts for the diversity of languages in this manner: Si-chom-pa Ma-so-its, the grandmother goddess of the Sea, brought up mankind from beneath the waves in a sack, which she delivered to the Shinau-av brothers, the great wolf-gods of his mythology, and told them to carry it from the shores of the sea to the Kaibab Plateau, and there to open it, but they were by no means to open the package ere their arrival, lest some great disaster should befall.

The curiosity of the younger Shinauav overcame him, and he untied the sack, and the people swarmed out, but the elder Shinauav, the wiser god, ran back and closed the sack while yet not all the people had escaped, and they carried the sack with its remaining contents to the plateau and there opened it.

Those that remained in the sack found a beautiful land, a great plateau covered with mighty forests, through which elk, deer, and antelopes roamed in abundance, and many mountain sheep were found on the bordering crags; *pine*, the nuts of the edible pine, they found on the foot-hills, and use the fruit of the *Yucca*, in sunny glades, and *nant*, the *meschal* crowns, for their feasts, and *chuar*, the cactus-apple, from which to make their wine; reeds grew about the lakes for their arrow shafts; the rocks were full of flints for their barbs and knives, and away down in the cañon they found a pipe stone quarry, and on the hills they found arrarumpive, their tobacco.

Oh! it was a beautiful land that was given to these, the favorites of the gods. The descendants of these people are the present Kaibabits of Northern Arizona. Those who escaped by the way, through the wicked curiosity of the younger Shinauav, scattered over the country and became Navahoes, Moquis, Sioux, Comanches, Spaniards, Americans—poor, sorry fragments of people, without the original language of the gods, and only able to talk in imperfect jargons.

The Hebrew philosopher tells us that on the plains of Shinar the people of the world were gathered to build a city and erect a tower, the summit of which should reach above the waves of any flood Jehovah might send. But their tongues were confused, as a punishment for their impiety.

The philosopher of science tells us that mankind was widely scattered over the earth anterior to the development of articulate speech, that the languages of which we are cognizant sprang from innumerable centers as each little tribe developed its own language, and that in the study of any language an orderly succession of events may be discovered in its evolution from a few holophrastic locutions to a complex language, with a multiplicity of words and an elaborate grammatic structure, by the differentiation of the parts of speech and the integration of the sentence.

A COUGH.

A man coughs. In explanation, the Ute philosopher would tell us that an *unupits*, a pygmy spirit of evil, had entered the poor man's stomach, and he would charge the invalid with having whistled at night, for in their philosophy it is taught that if a man whistles at night, when the pygmy spirits are abroad, one is sure to go through the open door into the stomach, and the evidence of this disaster is found in the cough which the *unupits* causes.

Then the evil spirit must be driven out, and the medicine man stretches his patient on the ground and scarifies him with the claws of eagles from head to heel, and, while performing the scarification, a group of men and women stand about, forming a chorus, and medicine man and chorus perform a fugue in gloomy ululation, for these wicked spirits will depart only by incantations and scarifications.

In our folk-lore philosophy a cough is caused by a "cold," whatever that may be, a vague entity, that must be treated first according to the maxim, "feed a cold and starve a fever," and the "cold" is driven away by potations of bitter teas.

In our medical philosophy, a cough may be the result of a clogging of the pores of the skin, and is relieved by clearing those flues that carry away the waste products of vital combustion.

These illustrations are perhaps sufficient to exhibit the principal characteristics of the two methods of philosophy, and though they cover but narrow fields, it should be remembered that every philosophy deals with the whole cosmos.

An explanation of all things is sought: not alone the great movements of the heavens, or the phenomena that startle even the unthinking, but every particular which is observed.

Abstractly, the plane of demarkation between the two methods of philosophy can be sharply drawn, but practically we find them strangely mixed. Mythological methods prevail in savagery and barbarism, and scientific methods prevail in civilization.

Mythologic philosophies antedate scientific philosophies. The thaumaturgic phases of mythology are the embryonic stages of philosophy, science being the fully developed form. Without mythology there could be no science, as without childhood there could be no manhood, or without embryonic conditions there could be no ultimate forms.

MYTHOLOGIC PHILOSOPHY HAS FOUR STAGES.

Mythologic philosophy is the subject with which we deal. Its method, as stated in general terms, is this: All phenomena of the outer objective world are interpreted by comparison with those of the inner subjective world. Whatever happens, some one does it. That some one has a will, and works as he wills.

The basis of the philosophy is personality.

The persons who do the things we observe in the phenomena of the universe, are the gods of mythology—*the cosmos is a pantheon.*

Under this system, whatever may be the phenomena observed, the philosopher asks, "Who does it? and why?" and the answer comes, "A god with his design." The winds blow and the interrogatory is answered, "Æolus frees them from the cave to speed the ship of a friend, or destroy the vessel of a foe."

The actors in mythologic philosophy are gods.

In the character of these gods four stages of philosophy may be discovered. In the lowest and earliest stage everything has life, everything is endowed with personality, will, and design; animals are endowed with all the wonderful attributes of mankind; all inanimate objects are believed to be animate; trees think and speak; stones have loves and hates; hills and mountains, springs and rivers, and all the bright stars have life. Everything discovered objectively by the senses is looked upon subjectively by the philosopher and endowed with all the attributes supposed to be inherent in himself.

In this stage of philosophy everything is a god.

Let us call it *hecastotheism.*

In the second stage men no longer attribute life indiscriminately to inanimate things, but the same powers and attributes recognized by subjective vision in man are attributed to the animals by which he is surrounded.

No line of demarkation is drawn between man and beast; all are great beings endowed with wonderful attributes. Let us call this stage *zootheism*, when men worship beasts.

All the phenomena of nature are the doings of these animal gods; all the facts of nature, all the phenomena of the known universe, all the institutions of humanity known to the philosophers of this stage, are accounted for in the mythologic history of these zoomorphic gods.

In the third stage a wide gulf is placed between man and the lower animals. The animal gods are dethroned and the powers and phenomena of nature are personified and deified. Let us call this stage *physitheism.*

The gods are strictly anthropomorphic, having the form as well as the mental, moral, and social attributes of men.

Thus we have a god of the sun, a god of the moon, a god of the air, a god of dawn, and a deity of the night.

In the fourth stage, mental, moral, and social characteristics are personified and deified.

Thus we have a god of war, a god of love, a god of revelry, a god of plenty, and like personages who preside over the institutions and occupations of mankind. Let us call this *psychotheism.*

With the mental, moral, and social characteristics in these gods are associated the powers of nature, and they differ from nature gods, chiefly in that they have more distinct psychic characteristics.

Psychotheism by the processes of mental integration develops in one direction into monotheism, and in the other into pantheism. When the powers of nature are held predominant in the minds of the philosopher through whose cogitations this evolution of theism is carried on, pantheism, as the highest form of psychotheism, is the final result; but when the moral qualities are held in highest regard in the minds of the men in whom this process of evolution is carried on, *monotheism*, or a god whose essential characteristics are moral qualities, is the final product. The monotheistic god is not nature, but presides over and operates through nature.

Psychotheism has long been recognized. All of the earlier literature of mankind treats largely of these gods, for it is an interesting fact that in the history of any civilized people, the evolution of psychotheism is approximately synchronous with the invention of an alphabet. In the earliest writings of the Hebrews, the Egyptians, the Hindoos, and the Greeks this stage is discovered, and Jehovah, Osiris, Indra, and Zeus are characteristic representatives. As psychotheism and written language appear together in the evolution of culture, this stage of theism is consciously or unconsciously a part of the theme of all written history.

The palæontologist, in studying the rocks of the hill and the cliffs of the mountain, discovers in inanimate stones the life forms of the ancient earth.

The geologist, in the study of the structure of valleys and mountains, discovers groups of facts that lead him to a knowledge of more ancient mountains and valleys and seas, of geographic features long ago buried, and followed by a new land with new mountains and valleys and new seas.

The philologist, in studying the earliest writings of a people, not only discovers the thoughts purposely recorded in those writings, but is able to go back in the history of the people many generations, and discover with even greater certainty the thoughts of the more ancient people who made the words.

Thus the writings of the Greeks, the Hindoos, the Egyptians, and the Hebrews, that give an account of their psychic gods, also contain a description of an earlier theism unconsciously recorded by the writers themselves.

Psychotheism prevailed when the sentences were coined, physitheism when the words were coined. So the philologist discovers physitheism in all ancient literature.

But the verity of that stage of philosophy does not rest alone upon the evidence derived from the study of fossil philosophies through the science of philology. In the folk lore of every civilized people having a psychotheic philosophy, an earlier philosophy, with nature gods, is discovered.

The different stages of philosophy which I have attempted to characterize have never been found in purity.

We always observe different methods of explanation existing side by side, and the type of a philosophy is determined by the prevailing characteristics of its explanations of phenomena.

Fragments of earlier are always found side by side with the greater body of the later philosophy. Man has never clothed himself in new garments of wisdom, but has for ever been patching the old, and the old and the new are blended in the same pattern, and thus we have *ataxism* in philosophy.

So in the study of any philosophy which has reached the psychotheic age, patches of the earlier philosophy are always seen. Ancient nature gods are found to be living and associating with the supreme psychic deities.

Thus in anthropological science there are three ways by which to go back in the history of any civilized people and learn of its barbaric physitheism. But of the verity of this stage we have further evidence.

When Christianity was carried North from central Europe, the champions of the new philosophy, and its consequent religion, discovered, among those who dwelt by the glaciers of the North, a barbaric philosophy which they have preserved to history in the Eddas and Sagas, and Norse literature is full of a philosophy in a transition state, from physitheism to psychotheism; and mark! the people discovered in this transition state were inventing an alphabet—they were carving Runes.

Then a pure physitheism was discovered in the Aztec barbarism of Mexico, and elsewhere on the globe many people were found in that stage of culture to which this philosophy properly belongs. Thus the existence of physitheism as a stage of philosophy is abundantly attested. Comparative mythologists are agreed in recognizing these two stages.

They might not agree to throw all of the higher and later philosophies into one group, as I have done, but all recognize the plane of demarkation between the higher and lower groups as I have drawn it. Scholars, too, have come essentially to an agreement that physitheism is earlier and older than psychotheism.

Perhaps there may be left a "doubting Thomas" who believes that the highest stage of psychotheism—that is, monotheism—was the original basis for the philosophy of the world, and that all other forms are degeneracies from that primitive and perfect state.

If there be such a man left, to him what I have to say about philosophy is blasphemy.

Again, all students of comparative philosophy, or comparative mythology, or comparative religion, as you may please to approach this subject from different points of view, recognize that there is something else: that there are philosophies, or mythologies, or religions, not included in the two great groups. All that something has been vaguely called *fetishism.*

I have divided it into two parts—*hecastotheism* and *zootheism.* The verity of zootheism as a stage of philosophy rests on abundant evidence. In psychotheism it appears as *devilism* in obedience to a well-known law of comparative theology, viz., that the gods of a lower and superseded stage of culture ofttimes become the devils of a higher stage.

So in the very highest stage of psychotheism we find beast devils. In Norse mythology, we have Fenris, the wolf, and Jormungander, the serpent. Dragons appear in Greek mythology; the bull is an Egyptian god; a serpent is found in Zendavesta; and was there not a scaly fellow in the Garden of Eden? So common are these beast-demons in the higher mythologies, that they are used in every literature as rhetorical figures. So we find, as a figure of speech, the great red dragon with seven heads and ten horns, with tail that with one brush sweeps away a third of the stars of heaven. And wherever we find nature worship we find it accompanied with beast worship. In the study of higher philosophies, having learned that lower philosophies often exist side by side with them, we might legitimately conclude that a philosophy based upon animal gods had existed previous to the development of physitheism, and philologic research leads to the same conclusion.

But we are not left to base this conclusion upon an induction only, for in the examination of savage philosophies we actually discover zootheism in all its proportions. Many of the Indians of North America, and many of South America, and many of the tribes of Africa, are found to be zootheists. Their supreme gods are animals—tigers, bears, wolves, serpents, birds. Having discovered this, with a vast accumulation of evidence, we are enabled to carry philosophy back one stage beyond physitheism, and can confidently assert that all the philosophies of civilization have come up through these three stages.

And yet there are fragments of philosophy discovered which are not zootheistic, physitheistic, nor psychotheistic. What are they? We find running through all three stages of higher philosophy that phenomena are sometimes explained by regarding them as the acts of persons who do not belong to any of the classes of gods found in the higher stages. We find fragments of philosophy everywhere which seem to assume that all inanimate nature is animate; that mountains and hills, and rivers and springs, that trees and grasses, that stones, and all fragments of things are endowed with life, and with will, and act for a purpose. These fragments of philosophy lead to the discovery of hecastotheism.

Philology also leads us back to that state when the animate and inanimate were confounded; for the holophrastic roots into which words are finally resolved show us that all inanimate things were represented in language as actors.

Such is the evidence on which we predicate the existence of hecastotheism as a veritable stage of philosophy.

Unlike the three higher stages, it has no people extant on the face of the globe, known to be in this stage of culture.

The philosophies of many of the lowest tribes of mankind are yet unknown, and hecastotheism may be discovered, but, at the present time, we are not warranted in saying that any tribe entertains this philosophy as its highest wisdom.

(To be continued.)

SPECTRAL EXAMINATION OF YTTERBIA.

By M. Lecoq de Boisbaudran.

The author has submitted the aqueous solution of the chloride to the induction spark, and has thus obtained a fine spectrum, formed chiefly of bands grouped between the solar rays, D and E. These bands are almost all shaded from the left to the right. The author thinks the existence of a specific emission spectrum for this new element the more important as its chemical reactions are not well characterized.

CHEMICAL CONSTITUTION OF ALKALINE AMALGAMS.

By M. Berthelot.

The author has prepared a series of alkaline amalgams, both liquid and solid, treated them with dilute hydrochloric acid, and measured the heat evolved. At the same time the analysis of the resulting liquid showed the proportion of alkaline metal contained in each, which is always less than that employed in the preparation. The heat of oxidation of amalgams rich in potassium exceeds that of amalgams rich in sodium. It is not the same with the amalgams richest in mercury, the heat of formation of such potassium amalgams surpassing that of the corresponding sodium amalgams by a quantity which may reach +8·6 cals. for $Hg_{12}K$ as compared with $Hg_{12}Na$. The oxidation heat of potassium surpasses that of sodium in an inverse direction and only by +4·7 cals. Hence the oxidation heat of potassium amalgam may be reduced to +4·8 cals., that of sodium in analogous conditions being +5·6 cals. This accounts for the displacement of potassium in a solution of potassa by sodium amalgam.

NOTES OF HOSPITAL AND PRIVATE PRACTICE IN SAN FRANCISCO.*

By H. GIBBONS, Sr., M.D.

AN annual report on practical medicine, from a standing committee appointed for the purpose, might be supposed to require a presentation of the last year's progress, changes, and improvements in that department, both in our own and foreign countries. Shrinking from a task so weighty, I have thought my brethren of the society would prefer something like the results of my observations and experience during eighteen years of hospital practice in San Francisco, as visiting physician, first of St. Mary's Hospital for six years, and afterward for twelve years of the City and County Hospital. This account will be drawn partly from notes and partly from memory; for I confess to the almost universal fault of medical practitioners, the failure to make and keep written records of professional work from day to day and from year to year, as ought to be done with regularity by every practicing physician.

It is scarcely necessary to premise that hospital patients do not present an average representation of the diseases of a community. They come largely from the ranks of the poor and destitute. Many have constitutions broken down by abuse and intemperance. The mental stimulus to recovery in a charity hospital is wanting in a great proportion of inmates, who prefer sickness in a hospital home to health in a world of strife and toil. In no other place is this more conspicuous than in California, where so large a number of the inhabitants are isolated from family and adrift in the world.

Besides, the inmates of hospitals in California are mostly men. Few women comparatively enter the wards, and scarcely any children.

CONSUMPTION.

Most prominent in the list of diseases, as to the number of its subjects, is pulmonary consumption. The victims of this malady flock to San Francisco from all parts of the State. In many instances they are in the advanced stage and come only to die. They never enter in the early period, when a chance of cure exists. By far the largest number are natives of Ireland. One would suppose that the change in the mode of life in coming from that country to this, the increased comforts and means of health, the nutritious animal diet, would fortify them against the invasion of phthisis. But the reverse appears to be the rule. This circumstance I have remarked for many years, until the conclusion has forced itself on my mind that the transition from a rugged mode of life, with simple fare and much exposure, to the comforts and luxuries of a higher civilization, is a hazardous experiment on the human constitution. We observe it particularly in the native Indians, who, when transferred from their wild life to the domestic service of the white population, become remarkably sensitive to the causes of disease, and, when taken sick, succumb almost invariably and without exhibiting any power of resistance. When I find an Indian in the hospital ward I very generally expect him to die, particularly if he has the slightest pulmonary disease. The same observation holds good, though not to the same extent, in regard to native Californians of mixed Spanish and Indian blood.

The white American race are less prone to pulmonary disease. A very small proportion of this class find their way into the hospitals—indeed a small proportion from any and all diseases. In private practice I think the same condition occurs—that is to say, there is much less tendency to pulmonary consumption among native Americans than foreigners. I am sure this has been the case within my own observation during the twenty-nine years of my practice in California. Transplantation of Americans from the Atlantic States to the coast has certainly not the same effect as transplantation of the Celtic race.

It is remarkable with what frequency the progress of phthisis is arrested when patients enter the hospital, even when they have but recently come from a climate much more congenial than ours. In quite a large number of cases they improve so far as to be able to leave the house and go to work. But such patients generally return in a few months. A still larger number remain, with scarcely the slightest change other than temporary exacerbations, for one or two years, or even longer, sometimes improving slightly in the long run. This was notably the case with three patients in the County Hospital, lately occupying three adjoining beds, and who had been in the wards for three years. They all declared that they were no worse than three years ago. In all these cases both lungs were studded with tubercles and contained cavities.

So far as relates to the prospect of cure, pulmonary phthisis, except in the very early stages, scarcely requires consideration. But no disease imposes on our profession more important duties. Before us is a fellow-being under sentence of death—a death not to be accomplished at a blow, but only after a long course of torture, years it may be, in which suspense, hope, and despondency are variously intermingled with physical suffering. The humanities of our profession, if nothing more, demand the interposition of all possible agencies to alleviate pain and console the drooping spirits, and spread comforts around the victim in his downward journey. This service is due also on behalf of the afflicted relatives. I mention this subject because it is too much the custom to regard our services as due only to curable patients, and to abandon to their fate those hopelessly sick.

COUGH AND NIGHT SWEATS.

There is one point in the treatment of all diseases which should never be lost sight of, viz., to give the patient a comfortable night, if possible. Night without sleep is always torture to the sick. Cough and night sweats are the two great hinderances of repose to the consumptive. For some years past I have been in the practice of depending largely on digitalis to allay coughing, adding to it such mixtures as are in common use, composed of expectorants and opiates. ℞. Tinc. belladonnæ, ʒ ij.; syrup. scillæ, ʒ ij.; sulph. morph., gr. iv.; syrup. tolu, ad ℥ iv. M. Sig.: A teaspoonful at bedtime, repeated if necessary. The proportions of morphia, etc., to be varied according to circumstances. In old and enfeebled cases the digitalis should be combined with anodynes. Of the value of digitalis for this purpose I am fully assured.

For night sweats, there is nothing equal to belladonna or atropia. A pill of oxyd. zinci, gr. ij., and ext. hyoscyami, gr. iv., is often effectual. But half a grain of ext. belladonnæ added to it forms the most efficient agent for the purpose I have ever tried. If it should not prove effectual in that proportion the quantity of belladonna should be increased. Atropia, in pill or hypodermically, is highly recommended by recent authors. The ancient remedy of aromatic sulphuric acid is also useful. A Dover's powder will often *prevent* sweating and procure a good night's rest. The dose should be fifteen grains. I seldom think of giving a smaller dose to an adult.

It is worthy of note that the night sweats are not only arrested by the treatment referred to, but that they seldom return when the remedies are withdrawn. In the two wards under my charge there are commonly about twenty-five cases of phthisis in the confirmed or advanced stages, and not more than one or two of them at any given time have nocturnal sweats. The same may be said of hectic fever. At the present time there is not a well marked case of hectic fever in the wards. Occasionally a patient complains of having had a chill or chills. Here a few anti-periodic doses of quinia or cinchonidia put an end to the trouble.

It is a matter of importance in the treatment of cough, night sweats, etc., to change the prescription frequently. All medicines are liable to lose their effect by continued use. Everybody knows this, and yet the knowledge does not appear to be sufficiently acted on by practitioners. In chronic diseases of almost all kinds, changing the medicine occasionally so gratifies the patient that there is healing virtue in the mere change. It is a common fault to adopt definite formulas in practice and adhere to a routine course. But he is the most successful practitioner who prescribes for each case itself, and who modifies his prescriptions according to effects and circumstances.

Pain is a common attendant of pulmonary and bronchial diseases. It may be pleuritic or it may be muscular or neuralgic. Within a few years past I have returned to the old-fashioned method of treating pains, which I had almost abandoned in obedience to fashion—*i. e.*, cupping and counter-irritation by mustard, croton oil, antimonial ointment, and blisters. Dry cupping and blisters have the preference. Where there is objection to the soreness of complete vesication the blister is kept in place only two or three hours and a poultice applied. Every day as I pass through my wards some of the patients ask me for a blister. So far from complaining of their pain, there is no appliance so welcome. The relief afforded by them is marked.

Hemorrhage is by no means a frequent accompaniment of phthisis in the hospital, nor is it generally followed by an aggravation of disease. On the contrary, in a large proportion of cases there is a decided improvement after a moderate discharge of blood. Again and again I have witnessed this, the improvement sometimes being almost permanent. Venesection was formerly employed as a remedy in pulmonary consumption, and often with reputed benefit. I well remember when it was in universal use for hemoptysis, and I can look back to individual cases in the early years of my practice when I bled the same patient time after time on the return of hemorrhage, with manifest relief of the distressed lungs. Dr. Rush employed venesection in advanced stages of phthisis to relieve the oppression and suffering, and his patients, according to his statement, were much comforted by the loss of blood without an apparent shortening of life. In these cases he called it the "anodyne of death."

FOODS AND DRINKS FOR CONSUMPTIVES.

Among the drinks employed is *dilute phosphoric acid*, used at the pleasure of the patient to acidulate the water. It will occasionally give permanent relief from the most annoying thirst. Cod liver oil is employed habitually, and the patients are allowed to take it in any manner they please. Some succeed best with it unmixed, while others find the combination with creosote to agree best with the stomach. The mixture of cod oil and iodine is sometimes productive of good.

Within a year or two extract of malt has been introduced largely in practice, both in Europe and America, as a concentrated nutrient, supposed to possess an extraordinary physiological adaptation in a large number of chronic disorders requiring the most perfect nutrition of the blood. It has been used quite extensively in some of the wards of the hospital, and in a number of my cases with excellent results. But I must confess not to have observed so much benefit arising from it as some writers have represented. Its combinations are various, for instance, with cod oil, iodine, the hypophosphites, etc. I regard it as quite equal to any form of fermented or spirituous drink.

The drinks last referred to are employed in my wards only in moderate quantities, and in the last stages of disease, and more for the gratification of the patient than with any expectation of benefit. The whisky treatment of pulmonary disease, both in hospitals and private practice, I have observed with some degree of attention and interest for many years. But I do not hesitate to declare that the cases of benefit from it which have come under my notice have been exceptional and rare. In the large majority of hospital patients the disease has been developed during the free use of alcoholic stimulants, and under circumstances which would warrant the conclusion that alcohol, so far from preventing, had aided in producing it. Some two years ago, owing to the exhaustion of the hospital fund, the supply of liquors was suddenly cut off for a week or two. A number of my patients, perhaps eight or ten, in the last stages of consumption, were getting from four to six ounces of whisky daily. I expected some of them to die from its sudden abstraction, but to my surprise they exhibited no bad results, but waited patiently and unharmed until the stream should again flow in its wonted channel. But my experience on that occasion detracted from the low estimate I had already formed of the value of alcohol as a supporter of life.

A preparation has been recently introduced under the name of maltine, which claims to embody the nutritive principles of all the cereals, and to be superior to any of the preparations made from barley alone. A limited use of it has impressed me favorably, and I believe it will prove to be a nutrient of great value.

Before leaving this subject let me impress on the minds of my hearers the importance and necessity of a State hospital for consumptives. The subject has been agitated in various quarters, and the members of our profession are called upon to press it on the attention of the people and Legislature as an institution required by the interests of humanity. Under present circumstances, a large number of our fellow beings are drifting continually from the interior to the seaboard with a delusive hope of saving their lives from the great destroyer, but actually stepping into the jaws of death. It is time that something were done to turn back this current. One or more health resorts in well-chosen localities in the interior would save many a life.

MALARIAL DISEASES.

The hospital wards are well supplied with malarial patients, almost all of whom come from the interior. The Sacramento Valley and Bakersfield are the two localities most distinguished in this respect. The cases from the region about Bakersfield are the worst. A few malarial cases are indigenous to San Francisco, coming from the flat quarter of the city on the southeast. It is quite common for individuals who have lived for some time in a malarious region without suffering to be seized with intermittent fever soon after changing their residence to San Francisco—the climate of the seaboard developing the disease which lay dormant previously.

The form of malarial disease generally presented is an irregular intermittent of the tertian character. The patient gives an old history of ague, cured and returning again and again. Nearly all have taken quinine liberally, but nothing else. An active mercurial cathartic comes first in the treatment, and then a few moderately large doses of sulphate of quinia or cinchonidia. The latter appears to be fully equal to the former in doses of one-fourth or one-third larger, and it is much cheaper. Ten grains of the sulphate of cinchonidia, night and morning, for two days, are pretty certain to arrest the disease. After that comes the necessity of preventing a return. For this purpose a repetition of an anti-periodic once a week regularly for a month or two is generally effectual. When the complexion denotes a long and deep impression of the malaricus influence, as it commonly does in the Bakersfield cases, something more is necessary; for instance, a course of nitro-muriatic acid, or, preferably, of the blue pill, with iron or other tonics. Arsenic is a famous old remedy in such cases, but I have seldom gained much benefit from it.

INTERMITTENTS.

Within the last year I have treated a number of cases of troublesome recurring intermittent entirely with tincture of iodine, in the dose of twelve to fifteen drops three times a day. So far the success of this method is well marked. In one of the worst cases, a man who had been suffering for many months, and whose skin was sallow and almost jaundiced, only one chill followed the institution of the treatment, after which he was entirely exempt. The iodine, however, was continued for several weeks, when he left the hospital in perfect health. It may be that the iodine treatment is peculiarly adapted to hospital cases, for the reason that such cases present hepatic or splenic or other visceral derangements to which is due their resistance to simple anti-periodics.

Modern medicine is boastful of its progress, and the present generation of medical men look back with pity, if not contempt, on the ignorance of their fathers. But it may well be doubted whether the treatment of many of our most common diseases has been improved in the least degree. Therapeutics has not kept pace with physiology, pathology, and the kindred departments. Men have expended their energies on more inviting pursuits than watching at the bedside and administering to the comfort and welfare of the sick. The interests of science have, to a great extent, superseded the interests of the patient. It is true that, sooner or later, all discoveries and all advance in theory and in principles must lead to improvement in practice. A few important diseases and a few specialties have already illustrated that proposition. But at least three-fourths of the commonplace derangements of health, such as demand the attention of the practitioner in his daily round, are almost overlooked in theurapeutic studies. In fact, some of our text books, while enlarging on diagnosis, pathology, and other heads, have curtailed the treatment as though it were of minor importance.

These remarks apply forcibly to the modern treatment of intermittent fever. With the majority of practitioners one word sums up the theurapeutics of this disease, viz., quinine. To prevent the coming paroxysm is an easy task, and this done, the patient is left to himself, with almost a certainty of a recurrence; or the medicine is continued day after day till its power fails, and then the dose must be increased. Despairing of permanent relief from regular means, the unhappy patient resorts to all kinds of nostrums, and is cured at last by some one of the really valuable combinations which quackery has stolen from the armamentarium of the profession.

TENACITY OF INTERMITTENT FEVER.

The tenacity with which the habit of intermittent fever clings to the system after the first invasion, even when no local lesions appear to have been established, and when the original cause is not renewed, presents a subject worthy the attention of every practitioner. In the treatment of such cases all our resources should be brought to bear. I need say nothing more in regard to the means demanded when visceral derangements exist. But it may be well to recall the ancient practice, much overlooked in modern times, of awakening a sensibility to the action of anti-periodics by active purging or vomiting. A dose of quinia, which would be impotent of itself as a preventive of ague, may be rendered thoroughly effectual by such preliminary treatment.

Although quinia stands at the head of anti-periodics, it may be replaced with advantage by cinchonidia, "dextro-quinine," or "cincho-quinine," when the patient has become inured to its action. From a trial of these preparations, I am well assured of their activity, as substitutes, in doses but slightly increased. "Dextro-quinine," which has been lately introduced, is undoubtedly a very active agent; and the testimony of a large number of disinterested men who have put it to the test would seem to place it nearly or quite on a level with sulphate of quinia. My own experience of it accords with this view.

The preparations referred to possess a value growing out of their comparative cheapness. The enormous consumption of quinia all over the world makes it a costly drug. At present the substitutes can be bought for one-half or two-thirds the price of quinia.

TYPHOID FEVER.

Typhoid fever is nearly always present in the hospital wards, but I do not recollect any period when there was so little of it as during the past winter. The cases are generally severe and protracted, sometimes hanging for days between life and death, but very generally terminating favorably. One would infer, from the previous condition and habits of the average typhoid hospital patient, that a large proportion would die. But the very opposite is true. So far as my observations extend, men of middle age, accustomed to a life of toil, hardship, and exposure, and careless in their general habits, withstand a siege of typhoid in the wards of a hospital decidedly better than younger persons of more vigorous and unimpaired constitution, with the better care and nursing of private practice. I can say with confidence that, for a period of fifteen years, the fatality among my hospital cases has not been nearly so great as in general practice.

* Read at the recent meeting of the California State Medical Society by the Chairman of the Committee on Practical Medicine. Published in the transactions for the years 1878-79.—*Pacific Medical and Surgical Journal.*

As to the communicability of typhoid from one person to another, I have never witnessed any evidence of it in California; and I believe this accords with the general experience of medical practitioners on the Pacific Coast. At no period perhaps during the last fifteen years have the wards of St. Mary's and of the County Hospital been free from cases of this disease, and in no instance have such patients been isolated or removed from the contiguity of others. During that period I have never known a solitary instance in which it could even be suspected that the disease was communicated either to other patients or to a nurse or attendant. In private practice, when the disease *originates* in a given locality, it appears to spread by contagion from one person to another. But this should be attributed to the continued operation of the original cause, the victims succumbing all to the same local influences one after another. Yellow fever presents a similar feature, in requiring some local influence to be superadded to the presence of the diseased individual, to enable it to spread. In other words, it is infectious and not contagious.

In regard to treatment, no peculiar method is pursued. Each case is vigilantly watched, and the local determinations, which are always imminent, promptly encountered. The very large doses of quinia which were in vogue a few years ago, a practice introduced from Germany, are now mostly abandoned. A few full doses may be useful in the early stage, and it may be given in connection with stimulants in the stage of exhaustion. But stimulants I always avoid in the first stages, reserving them until they are called for by the failing strength. Milk is the best basis of diet, and buttermilk may be employed if agreeable to the patient.

Hemorrhage, either from the nose or the bowels, has been rather a rare attendant of typhoid in my observation, particularly in the hospital. From the bowels it has occurred more frequently and with greater fatality in my private practice, and particularly when convalescence had begun.

RHEUMATISM AND NEURALGIA.

Rheumatism and neuralgia are great pests in a hospital. A few years ago salicylic acid and its combinations were introduced for the treatment of acute articular rheumatism, and they gained the highest position, although they have not fully maintained their reputation anywhere. I have continued their use and regard them as superior to everything else. To be effectual they should be administered in large doses—ten grains of the acid or its combination with soda every two hours. An anodyne at night greatly enhances the effect. But very often all the benefit attainable from this remedy ends in a week or ten days; and then iodide of potassium, colchicum, and other remedies should be substituted. The more acute and violent the disease the greater the benefit to be expected from salicylic acid. The most violent and intractable case of acute articular rheumatism that I have seen for many years occurred two years ago in my private practice, the patient being a lady of middle age. Salicylic acid was rejected by the stomach, and opiates, both by stomach and hypodermically, utterly failed to relieve the pain. Quinia only distressed the head and had to be abandoned. I finally resorted to salicin, in doses of ten grains every two or three hours. A few doses gave decided relief, and it was continued for four or five days, the patient taking in all nearly an ounce of salicin, with no appreciable effect on the head, or in any other way than to cut short the disease and accomplish a complete cure in one week. It was the best pronounced and most satisfactory case of abortion of acute rheumatism that ever fell under my notice.

Colchicum combined with morphia furnishes excellent results in sub-acute rheumatism, especially in gouty complications. I generally give a drachm of the tincture with one-twelfth to one-eighth gr. sulph. morph. three times a day. After a few days purging comes on, when the medicine must be suspended. Relief is simultaneous with the catharsis, but the latter commonly continues and is liable to give some trouble. In obstinate cases iodide of potassium may be added to the colchicum mixture.

There are always on hand numerous old cases of chronic rheumatism, often of two or three years' standing, which torment both patient and doctor. They are mostly local, and in the majority of cases seated in one or both of the lower extremities. The pain will sometimes gradually recede under treatment from the hip to the knee, then to the ankle, then to the instep or heel. In one or two cases it made a final lodgment in the latter, and was as invulnerable to the weapons of medical art as if the heel had been dipped in the Styx.

The treatment of these cases requires some ingenuity, particularly if the patient has been so long accustomed to a pain as not to know when it ceased, or if he has made up his mind that a hospital is a good permanent home. Local applications of energetic character must be made, and repeated with industry, such as tincture of iodine, rubefacients, blisters, antimonial ointment continued till it produces free pustulation, etc. Much benefit has been derived in some instances by wrapping up the knee, or ankle, or foot with eucalyptus leaves, renewing them daily for a week or more. These leaves are an active stimulant to the surface, and will produce vesication if their use be long continued. Showering the part affected for ten or fifteen minutes daily under the hydrant has cured some obstinate cases. It is sometimes proper in these cases to resort to hypodermic injections of morphia, atropia, or chloroform. In sciatica, the injection of ten minims of chloroform at bedtime is very efficacious. It is best thrown in deeply into the cellular tissue. Injections of water alone occasionally answer an excellent purpose. There is no difficulty in weaning from his habit an old subject of hypodermic medication with morphia by substituting water, provided, of course, the secret is concealed from him. I had one patient of this kind who was put to sleep every night for a fortnight by a hypodermic injection of cold water, and who finally himself proposed to abandon it, which was successfully done.

Aconite, by hypodermic injection, is a powerful agent for the removal of these chronic, localized pains. It may be used in the form of aconitia, one-sixtieth to one-thirtieth of a grain, dissolved in water, or in the form of tincture of the root. I prefer the latter in the quantity of about eight or ten drops. The only objection to it is the severe pain which it produces. This will be mitigated and the value of the injection enhanced by adding the eighth of a grain or more of morphia. But advantage may be taken of the effect of aconite when the pain is kept up by *attention*, or in suspected malingering. A hypodermic injection of ten drops of tincture of aconite, given every night, has induced more than one of my old hospital habitués, after very few repetitions, to walk forth with alacrity and bid a permanent farewell to their old home.

DISEASES OF THE HEART.

Diseases of the heart and large arteries are common in the hospital. Valvular lesions, as might be expected, are traceable in the majority of cases to a rheumatic origin, but in no small number this history is wanting. The mitral valve is the seat of lesion in the worst cases, the usual train of disturbing symptoms growing out of regurgitation. Some very interesting cases of hypertrophy from aortic insufficiency or stenosis occur from time to time. The largest heart I ever saw was in a young man, a patient in St. Mary's, who came under my care with extreme orthopnea and extensive anasarca. Gangrene in both legs resulted from the cutaneous distention, and extensive sloughing ensued and endangered his life. But the process of repair set in and he recovered so as to lie down at night and rest with comfort. His appetite and strength returned, and he appeared almost restored to perfect health. One evening, after eating a hearty supper, he fell back and died suddenly. On dissection, the secret of difficulty was found to be a congenital contraction of the aorta at a point two or three inches from the heart, where the artery scarcely admitted the end of the little finger. The patient was a laboring man, of large stature and of exemplary habits. Except the heart, all the internal organs were sound. The dropsy and impeded respiration had no other cause than the mechanical obstruction of the blood current. Had he lived a quiet and sedentary life the contracted blood vessel might not have interfered with his length of days.

Patients with aortic aneurism often trace its origin to an accident or muscular effort which was followed by pain. In some cases the proof of this seems clear; mostly, however, it is mere conjecture. With great uniformity the subjects of aneurism are men who have been accustomed to lifting heavy weights in a stooping posture. Stevedores are particularly its victims. The patients have been mostly, but not all, hard drinkers. As a rule, the aneurismal lesion is accompanied with atheromatous degeneration of the arterial coats, showing it to be dependent on a general rather than a local cause.

After using and witnessing the use of the various expedients proposed for the cure of aortic aneurisms, I have ceased to treat them with the expectation of a cure. To arrest their progress is the only practical indication. This is best done by bodily repose, or rather abstinence from active exercise, and arterial sedatives, such as veratrum viride and digitalis. Other means are required for special conditions. Under this treatment well-developed aneurism may be kept in abeyance for years, the patient meanwhile enjoying life without material suffering.

JAUNDICE.

There are always cases of jaundice in the hospital wards—idiopathic jaundice, if the term be admissible, in which no organic lesion can be detected. About a year ago there existed an epidemic tendency to jaundice, which was observed in outdoor practice, not only in San Francisco, but in other parts of the State. For a period of six months or longer, patients affected with various diseases exhibited the deposition of bile in the conjunctiva and skin. But besides these slight and generally transient developments, numerous instances occurred of well-pronounced jaundice, some of which were in children.

The treatment pursued by me is simple and without novelty—mainly blue pill and nitro-muriatic acid. The former is given continuously in small doses, suspending it on the first indication of ptyalism, and resuming it when proper. Five drops of the acid three times a day is the minimum dose. Attention to the bowels is a matter of course. But I would mention one important point, namely, that diarrhea, or a too loose condition of the bowels, is unfavorable to cure. There ought not to be more than one daily evacuation. Success has uniformly attended this treatment when the jaundice has not been due to chronic lesion.

Cases of cirrhosis, cancer, fatty and amyloid degeneration, etc., of the liver, are nearly always present in the wards of a large hospital. I might greatly extend these notes by referring to them, and to lesions of the kidneys, spleen, stomach, and other organs. But I am afraid that there is not enough of novelty or originality in my report to warrant its further extension.

AURAL THERAPEUTICS.*

THE reason is very often given for not recognizing aural surgery as a special department, that its advocates do not cure the many chronic cases of deafness that afterward float about from one practitioner to another, informing each that they were under the care of a specialist, without being improved. Gentlemen, is not this the case with all chronic diseases, no matter which organ of the body is affected, except it be a functional disorder? Every day of our life we hear of cases of diseases of the brain, eyes, lungs, heart, liver, kidneys, spleen, bladder, uterus, ovaries, and muscular apparatus, being discharged as incurable or to die, from the hands of the best and most learned in diagnosis, unexcelled in their knowledge of anatomy, physiology, and pathology; even experts in physical diagnosis. In the various acute affections of the human ear, I can refer with pride to the record on our clinical books, and show as good results as in any other of the out-door departments. And in our chronic cases of diseases of the ear, where there were no absolute changes, such as destruction of the organ or alteration of tissue, which so frequently follow long protracted disease, the result of our treatment will be found equal to any other department in the short period it has been in operation. (See report submitted to the Board, September 30th, 1878.) A glance at the various tables in my "Manual of Diseases of the Ear,"† pages 56, 57, 58, and 59, from various authors, and our best authorities in aural surgery and medicine, will serve as a guide to the frequency of aural disease, with some results of treatment. I will briefly extract a few facts from them: of six hundred cases carefully recorded, in Howard Hospital and in private practice, the number cured was 241, improved, 194. In a similar table by Dr. Schwartze, of Halle, of 332 cases, 145 were cured and 122 improved. Of Dr. Moos' cases (chronic aural catarrh), 100 in all, there were 17 cured and 64 improved; and Prof. Gruber cured 326 cases and improved 128, in 763 cases.

A view of tables of cases will show a great preponderance of chronic affections, very many of them the result of neglected acute attacks, that were manageable if they had been diagnosed and treated in their early stages. The duration of the six hundred cases before referred to will give an idea of the neglected condition of many of the cases received by us for treatment, and our results will compare favorably, we think, with the condition of the patients when received:

One year or less					277
Between 1	and	2	years		35
" 3	"	4	"		25
" 4	"	5	"		19
" 5	"	10	"		107
" 10	"	20	"		82
" 20	"	30	"		36
" 30	"	40	"		12
" 40	"	50	"		4
Over 50			years		2
" 75			"		1

In all diseases the prognosis is a matter of the gravest importance; and, young gentlemen, you who are about to graduate, see that you make this a matter of careful study, and commit to memory the prognosis in most of the prominent diseases, so that you may inform your patient as to the chances, based on carefully recorded experience of others, and, after a time, when you have had a sufficient number of cases on your own account. I will refer you to my teachings on this subject, and will advise, in passing, not to give a hasty prognosis in any case, for it will depend largely upon the severity of the attack, the general health of the individual, the hereditary tendencies, and upon the duration. The great majority of practitioners, and we may say, with truth, even many general surgeons, are not well informed as to the nature of obscure diseases of the ear, and some of them are not provided with proper mirrors or a speculum to examine the ear, nor with a suitable text book, so as to understand how the ear should look when diseased (at this point the lecturer exhibited several illustrated works on diseases of the ear). Indeed, but few can tell a purulent otitis of the middle ear, with perforation of the membrana tympani, from a diffuse otitis of the meatus, and they constantly confound it with chronic suppuration of the external auditory canal, under the old term of "otorrhœa." Again, in summing up from my tables, the cases show that, instead of external diseases of the ear, the majority of cases are serious and dangerous diseases of the internal and middle ear, for we find there are 742 cases of chronic inflammation and suppuration of the middle ear, to 138 cases of chronic inflammation of the external auditory canal. I am constantly receiving from well educated graduates of our own and other schools, cases which, most unfortunately for the patients, illustrate this want of knowledge. A few lectures and demonstrations on the patients received at our clinic would most effectually prevent such dangerous mistakes.

I will now pass to the consideration of a few of the remedies which I find especially valuable in aural disease, and will endeavor in the brief time at my disposal to show as many cases as I can, so that you may not make such mistakes as those to which I have referred.

The action of aconite on the circulation and respiration is somewhat remarkable. After a few doses, of one to five drops of the tincture of the root, or the $\frac{1}{120}$ of a grain of the nitrate of aconitia, the number of the heart's beats are reduced to one-half the normal standard, say to forty in the minute, while it renders the breathing very much slower. Aconite affects the muscular substance of the heart and also the ganglionic nerves. Now, how will aconite act so as to be useful in ear diseases? In acute catarrh of the middle ear, with tonsillitis, in which the skin is dry, hot, and burning, its judicious and careful use causes the skin to become moist, and subsequently bathed in a profuse perspiration. Acute otitis media, associated with pharyngitis, rarely fails to succumb in twenty-four hours, and the tonsils, from being livid, red, glazed, and dry, will become reduced in size and bathed in mucus. And then, by the proper use of the spray or gargle of astringents, and nitrate of silver, with the Politzer air douche, the noises, pain, and deafness will disappear. Another form of ear disease is chronic catarrh of the middle ear, in which the patient is very liable to catch cold, as it is often expressed. This is followed by subacute inflammation of the fauces, which become swollen, red, and dry, this condition passing into the tonsils, uvula, arches of the soft palate, and up the Eustachian tubes, or downward to the chest. This condition may have existed for years, with constant relapses, the whole appearance of the throat and orifices of the Eustachian tubes never becoming natural, but often clogged with tenacious mucus, or even by pus, also with patches of enlarged follicles. At other times the disease is found chiefly in the middle ear, in which, after the acute stage, there still remains fluid. This condition will be benefited by aconite, but it must be combined with belladonna or jaborandi. The dose is from one to three drops of the tincture of aconite with five drops of the tincture of belladonna, every three hours. The success of this treatment will depend upon the care with which it is followed up by a careful hardening and cleansing of the parts by means of cold outside the throat and astringents inside; above all, with the free use of quinine, in conjunction with nourishing food and outdoor exercise in fine weather. Now, there is a certain caution to be used in the use of aconite and belladonna; do not exceed the full dose in the twenty-four hours, nor trust the patient or nurse without careful watching, as aconite is an exceedingly powerful poison; one-twelfth of a grain of the crystallized alkaloid is sufficient to kill an adult. In a case of recovery from a poisonous dose (one ounce Fleming's tincture), the agents employed were twenty minims of the tincture of digitalis, hypodermically injected, and after twenty minutes, the man having revived sufficiently to swallow, a fluid drachm of the tincture of digitalis, with ammonia and brandy, was given to him, and repeated twice within the hour, and the man recovered. The treatment of belladonna poisoning is evacuation of the stomach, opium, and stimulants. Externally heat is applied, with flagellations, artificial respiration, etc.

Digitalis influences the ganglionic nerve centers of the heart and capillaries in such a way as to impart steadiness and force to the muscular fibers of the former, and improved elasticity to those of the latter, thus causing the streams of circulation to move with an equable and natural current into and out of every organ. By this regulation of the cerebral current of circulation various functional disturbances of the brain, ideal as well as sensory, like delirium, pseudopsia, tinnitus aurium, are ameliorated or permanently removed. *Quinine*, if the dose is large enough, acts on the auditory nerve centers, producing temporary tinnitus aurium or subjective sounds, which are modified by the use of hydrobromic acid in combination. It is also true of quinine that it is curative in certain forms of ear diseases of an intermittent character, or malarial neuralgia of the third branch of the fifth or tri-facial nerves. Also in distressing tinnitus aurium arising in certain furunculous disease of the ear, in which the noises are a reflex irritation or action of

* A Clinical Lecture, delivered February 27th, 1879, by Laurence Turnbull, M.D., Aural Surgeon, Jefferson College Hospital. Reported by Charles W. Karsner, M.D., Assistant to the Aural Department, Jefferson College Hospital.

† J. B. Lippincott & Co., Philadelphia.

the nervous system. *Strychnia* and its salts are agents which act in producing a reflex action of the nervous system, and especially the spinal nerves; by its use loss of power or atrophy of the auditory and other nerves which supply motor and sensory action to the ear is relieved or improved. Strychnia is best administered by hypodermic injections of the sulphate, beginning with one-sixtieth of a grain daily, and gradually increasing, till by the end of a month the system of the individual may become, as we say, so tolerant as to bear one quarter of a grain, yet we have known at such a time a slight contact or blast of air to produce convulsions or cause complete rigidity. The centers of the frontal lobes and the cerebral sensory centers, both of sight and hearing, are less amenable to the influence of strychnia than the spinal cord.

The *bromides of potassium, sodium, lithium, and ammonium* exert upon reflex action an influence the opposite of that induced by strychnia; in diseases of the ear they modify it, and their influence extends to the sensory and ideal centers. It is possible by these agents to dull without destroying the reflex sensibility of the nervous system, and to act directly upon the cerebrum and spinal nerves, so that the visual and auditory centers perceive sights and sounds, and report them to the frontal lobes, where they are received with indifference. Another phenomenon which follows the administration of the bromidal preparations is that of sleep. This has been produced by its action on the vaso-motor nerves, producing contraction of the capillaries, and especially so of those of the brain. Bromide of potassium in very large and repeated doses, on account of adynamia, which it sometimes causes, must frequently be suspended. In addition to weakness, retardation, and irregularity of cardiac action, the bromide of potassium may give rise to præcordial pain, or will sometimes improve the appetite and nourish the patient. In such cases it should be taken at meal times, or after, in a tumbler of milk. Bromide of sodium is a milder preparation, more easily borne by the stomach, and is to be preferred in the cases of nervous women, old people, or children, as it can be added to soup in the place of common salt. This can be employed in the various forms of nervous affections of the ear, in the dose of 15 to 30 grains in solution with sirup of red rose, as it is readily deliquescent, and will not keep in powder. The bromide of ammonium is a more stable preparation, and is best given with sirup of orange peel, in doses from one-half to two drachms daily. This acts well in all spasmodic affections of the throat, larynx, and glottis in children, as well as in hysterical persons, who often suffer from subjective noises in the brain and ears. Then there is another of the class which is termed the brominated camphor. This, like the hydrate of chloral, is an antidote to strychnia in doses of 15 to 30 grains; also useful in nervous palpitations of the heart in 3½ to 4½ grains several times a day. It has also been found useful in sexual excitement and pollutions, attended with various noises in the head or ears, but in very stubborn cases the bromide of potassium with opium or tincture of veratrum viride (two or three drops on sugar, continued until slowing of the pulse is attained) acts sometimes much more satisfactory. In irritation from cold of the throat, nose, or bladder, in doses of from three to eight grains, we have found the bromated camphor to remove the annoying difficulty. The *bromide of zinc* is to be prescribed only in pill, from 1½ to 2 grains, and gradually increased to 6 grains. It is found particularly useful in hysterical muscular spasm of the intrinsic or extrinsic muscles of the ear.

Chloral hydrate is very valuable in the pain of megrim, clavus, sick headache, in five-grain doses every three hours. This agent is also very useful when associated with the bromides in neuralgia of the fifth, also the occipital and auricular nerves of the ear.*

EXHIBITION OF CASES OF EAR DISEASE.

The first set of cases which the doctor brought before the class were diseased conditions of the auricle, as fibrous and other tumors, eczema, hemorrhagic and polypoid growths of the meatus, furunculous abscesses, with desquamative epithelial inflammation, and compared these, showing them the ordinary form of impacted cerumen, proving how very important it was to make a correct diagnosis, which, he stated, could best be accomplished by having seen and examined for themselves each variety of ear disease.

The second series of cases consisted of acute otitis media, catarrhal and purulent, occurring as the result of cold and of the exanthemata, the first occurring in the adult, the second in children. The new method of treatment was then shown the class by means of the "Gruber cones" of gelatine and glycerine, which he considered a great improvement over the old form in the hands of the patient.

The third class, six in number, which the doctor exhibited, were cases of each variety of perforated membrana tympani, with disease of the middle ear, from the minute point of perforation to the case of almost entire loss of the membrane; also a rare case in a young lady who had a double perforation in one ear and a single perforation in the other, which followed pneumonia. The lecturer brought one case of perforation before the class, who was able, when the class was very still, to pass the air so audibly through the Eustachian tube and perforation as to be heard by almost all present. Three clinical assistants went round the class, and with the proper speculum and mirror were able to show the students most of these interesting cases. The great importance of careful cleansing of the ear was dwelt upon, and all the most approved apparatus were shown and their mode of use explained.

A fourth class of cases were then exhibited, of acute and chronic disease of the ear without perforation, and the doctor dwelt at some length upon alcohol and tobacco disease of the throat, Eustachian tubes, and middle ear, and in an illustrative case showed the decided improvement from giving up entirely the use of the *weed*, and the advantages of injections of warm solutions of glycerine in water into the middle ear by means of the Eustachian catheter and air douche.

At the conclusion of the lecture, which was listened to with deep attention, the doctor dwelt upon the importance of each of the new graduates being prepared to treat diseases of the ear properly; because the first case which will present itself on opening an office may be an adult suffering from acute disease of the ear, or some little one on the very brink of convulsions from the same cause, which, if not recognized, might be bled and blistered for disease of the brain.—*Med. and Surg. Reporter.*

* For details of the action of this drug the lecturer referred to his "Manual of Anæsthetic Agents, and their Employment in the Treatment of Disease," second edition, p. 209, published by Lindsay & Blakiston, Philadelphia, 1879.

APPEARANCE OF THE TONGUE IN DISEASE.

By J. A. HENNING, M.D., of Red Key, Ind.

WHEN a physician commences to examine a patient, generally his first request is, "Let me see your tongue." The patient protrudes it a few moments, and other symptoms are examined as promptly. The doctor rarely stops to study what condition of the system is expressed by the appearance of the tongue, but only to see whether the secretions are torpid or lively. I have noticed physicians, and even professors of colleges, to thus hastily examine the tongue and say nothing about its peculiarity or indications. When I first commenced to practice I would, as is the custom, look at the tongue, but I did not know what I could learn from it. Yet I knew very well that the peculiar appearance in different forms, and even in the same disease, with its changes, meant much more than I knew about it. Then I would look at my text books, but as a general thing they gave me very little light on it.

The appearance of the tongue will tell us, 1st, The condition of the digestive organs. 2d, Function of nutrition and assimilation. 3d, The nervous system. 4th, The condition of the blood. All of which we want to know from every patient before we can make, in many cases, a rational or scientific prescription.

Some of the peculiar appearances of the tongue in numerous diseases are the broad, white coated, pallid tongue; or the deep red, sleek tongue. Then we have the pinched, shrunken, elongated, full, yellow furred, violet, dark brown tongue, with many other varieties.

We shall not attempt to describe all the above appearances as found in various diseases, but only call attention to the first two forms.

1. The broad, pallid, white furred tongue, whether found in acute or chronic disease, and even in the same disease at different stages, it matters not, always indicates the want of the alkaline elements of the body. The patient that has such a tongue never wants an acid drink, because his system is already acid; whether the acid is in the stomach or blood, it matters not. In such cases, with our usual prescription we must give alkalies, such as sulphate or bicarbonate of soda, in order to neutralize the acid. Then, and not till then, will our remedies act kindly and much more promptly, and the patient improve more rapidly. Now if acids are prescribed when the tongue is broad and pallid, the system being full of acids already, it will be seen at once that no improvement could or should be expected. I remember, before I was aware of this rule, I could not see why my remedies did not improve the patient; but now I give the proper alkali, removing the acid; then the remedies act more promptly, the tongue changes to a better appearance, and the patient improves correspondingly. This acid condition of the system is probably more often found in acute than in chronic diseases; at least that is my observation. It needs but a trial to test this principle; I have never known it to fail. I do not pretend to explain why the tongue looks thus when there is a superabundance of acid in the system.

2. The deep red, sleek tongue, with a slight coat at the base, indicates just the opposite condition; here the system is in an alkaline state, no matter in what form of disease. Then some kind of acids must be given to neutralize the superabundance of the alkali before other remedial agents will or even can have a good effect. All persons that have this peculiar tongue desire acid drinks. This tongue is often, though not always, seen in erysipelas, typhoid fever, and many other diseases, where the tr. chloride of iron or muriatic acid will be the leading remedies. But if the system was in an acid condition, known by the broad, pallid tongue, those remedies would do more harm than good. Now I do not wish to inculcate the idea that alkalies or acids will cure any disease, but the above appearances of the tongue are indicative of specific physical conditions, and those remedies are adjuvants, paving the way and assisting specific remedies.

The other peculiar appearances of the tongue above named each have a significance, and one very important to learn; not only being a material element in making a diagnosis and prognosis, but are also indicative of treatment. Many of our best remedies fail in chronic diseases just for the want of this simple knowledge, and this is one reason why remedies will remove the disease in one patient and fail in another, though they may have the same disease and the same remedies. Take rheumatism: sometimes an acid treatment and sometimes an alkaline treatment will cure. Failure often lies in the physician, not in the remedies. The grand secret is to know which of the two is demanded for the particular form of the disease.—*Med. and Surg. Reporter.*

STRYCHNIA POISONING TREATED WITH CHLORAL HYDRATE, APOMORPHIA, AND ELECTRICITY—RECOVERY.

By C. M. WORTHINGTON, M.D., Oakland, Cal.

ON the seventh of July, 1879, at 10 A.M., I was summoned to a room on the same floor with my office, to see a woman screaming from the agony of excessive pain. Her cries could be heard some distance off through her open window.

When I entered her room, tonic muscular spasm was so strong she could not speak, nor could she open her mouth. Returning to my office for Gaffee's batteries (which I had been using when summoned) I applied the positive pole over the cervical vertebræ, and the negative I passed over the muscles of the throat, jaws, and sympathetic nerve, which relieved the spasm. She then whispered, "I have taken strychnine." As quick as I could bring it from my office, say in two to three minutes, I gave her 30 grs. chloral hydrate in a glass of warm water. This I followed with ¼ gr. apomorphia, hypodermically. She very soon became more quiet, and all the effects usual from apomorphia were realized except emesis. The prostrating effects did not pass off until near 12, when the spasms increased in strength; then 30 grs. chloral hydrate more were given, which relieved the spasms so much that nothing more was done until 2:30 P.M., when another 30 grain dose of chloral hydrate was administered, mixed with an ounce each of ol. amygdalæ and aq. camphoræ. This produced pain in the stomach, which was relieved by hot applications to the abdomen and lower extremities.

At 5:30 P.M. she was so much better that she took a few spoonfuls of soup and strong coffee. When I returned at 8:30, her jaws had been locked from 6, so that she could not move her tongue to speak a word, nor could my efforts open her mouth. Again I applied the battery, which relieved her as in the morning, when 30 grs. more of chloral was given; this gave relief, and was the last administered. She passed no urine for twenty-four hours, and then very little, say eight to ten ounces.

The chloral produced stupor but not sleep, and there was no time in the whole course of treatment when she did not know anything going on around her. My conclusions are:

1. She did not get quite enough in the stomach to destroy life, because of its insolubility in water; for enough was left undissolved in the glass from which it was taken to kill several persons. And after making several tests, and giving some to a cat which soon died, I had enough in the glass sealed up for many tests.

2. That apomorphia should always be used as soon as a case is seen (this I carry in my pocket as I do my syringe) in place of the stomach pump, for its anti-spasmodic effects, and not to produce emesis. This cannot be done, owing to the paralyzed condition of the esophageal and gastric muscles. The use of the pump is loss of time for antidotes, which cannot be absorbed if introduced into the stomach and removed with the pump.

Brown-Séquard says: "The action of strychnia consists in an increased nutrition of the spinal marrow, by which excess of nutrition the reflex faculty becomes intensified." Kölliker says: "In whatever manner the agent acts, it does so upon the nervous centers alone and not upon the nerves themselves or on the muscles," and "that the loss of power and excitability in muscles tetanized by strychnia is a consequence of this previous overexcitement." Marshall Hall says: "If the milder form of strychnism be allowed to remain quiet it will recover, while on the other hand, if continually excited it will certainly die." Thus all agree that "quiet" must be secured to the nervous system before we can hope for cure, and for that purpose my remedies have been employed. Therefore,

3. The *anti-spasmodic* and *soothing effects* of *chloral hydrate* have long since impressed me favorably as of great value in cases poisoned by this drug. I have seen chloroform fail in many cases from producing, when the first spasms were very strong, spasm of the glottis, the first inhalation stopping the respiration and compelling its discontinuance. Whatever is done must be done quickly, or the case is lost. Therefore, as soon as the spasm of the throat was relieved, I gave the chloral hydrate as above, and from the result here presented shall use it whenever a case comes to my hands, or until proof is adduced of its insufficiency.

The patient is now (10th) well, except shock from the extreme suffering caused by the violent spasms, and is going about as though nothing had occurred.—*Pacific Med. and Surg. Journal.*

ROYAL ASTRONOMICAL SOCIETY.

AT a recent meeting of the society, in London, Dr. Henry Draper, of New York, was called upon to read his paper relating to his discoveries of oxygen in the sun.

He said: My first spectrum photographs were taken with a couple of Bunsen batteries, an induction coil giving a spark of ½ in., and a Hofmann direct vision spectroscope. The length of the spectrum from G to H was about ½ in. On examining a series of photographs of the fluted spectrum of nitrogen, taken with a juxtaposed solar spectrum, I was struck with the coincidence of some of the bright bands in the two spectra, and pursued the subject further. The electrical part was made more and more powerful as the research proceeded.

At first I made use of a 2 in. induction coil, then of a 6 in., and this was in turn succeeded by a Ruhmkorff coil capable of giving a spark of 17 in., and the battery was eventually superseded by a Gramme dynamo-electric machine, which can produce a current powerful enough to give between carbon points a light equal to 500 standard candles. When this machine is properly applied to the 17 in. induction coil it will readily give a thousand 10 in. sparks per minute. These being condensed by 14 Leyden jars, communicate an intense incandescence to air, and light enough is produced to permit of the use of a narrow slit with large dispersion, and of a collimator and telescope of long focus.

Since 1877, when the first publication of the discovery of oxygen in the sun was made, still further improvements, especially in the optical parts, have been completed, so that I am now enabled to photograph the oxygen spectrum with four times the dispersion then employed. The Gramme machine is driven by a petroleum engine of one and a half horse power, which gives a very constant current. One of the most important improvements in the research was in the use of a spark compressor to condense the spark between the poles. Under ordinary circumstances, the spark follows a zigzag course.

I at first made use of two plates of glass, compressing the spark into a narrow space directed toward the slit, but I have since employed a soapstone compressor, with a narrow chink in it directed toward the slit. The lines seen in the spectroscope are thus greatly increased in brightness, and the intensity of the spectrum is much more nearly constant, owing to the fact that all the discharges take place directly in front of the slit. With such a spark compressor I have been able to make use of two bisulphide of carbon prisms of 2 in. aperture, and an observing or photographing lens of 6 ft. 6 in. focal length, and although the total light of the spark in air is not greater than that of a single candle, I have succeeded in obtaining photographs of the spectrum on a scale of 8 in. from G to H, that is, about half the size of Angström's chart in the "Spectra Normale du Soleil." By comparison, I have found that when the same current is used for volatilizing iron, the light is sixty times stronger than the most vivid incandescence of air that I have produced.

The spectroscope is about one inch long, and opposite the lower half is placed a right angled prism, which serves to throw on the plate a solar spectrum derived from a beam of light received from a heliostat, and we can ascertain, by observing with a magnifier just previous to the exposure, whether the adjustments are in the best order. [Applause.]

Dr. Draper then showed some exquisitely sharp negatives of the solar and oxygen spectra which he had obtained, and handed round some paper enlargements, some 2 ft. long, for inspection by the meeting

Mr. Ranyard said: After the reception that has been given to Dr. Draper, I do not think that I need say anything about the importance of the research he has undertaken. When he sent over his former photographs on a much smaller scale, I then ventured to estimate the probability of his having proved his case as some thousands to one, but these photographs are on four times the scale of the old photographs, and I should like to point out how enormously the probability of his case has been increased. It has not merely been increased four times, but the value of every coincidence that he shows has been increased fourfold, and as there are eighteen oxygen lines shown in the photographs, he has increased the probability of his case by four to the

power of eighteen; a very large number, many thousands of millions of times

But, besides the coincidence in the position of the lines, there is the similarity of their relative brightness to take into account. Let us suppose that the breadth occupied by dark lines in the solar spectrum is equal to the breadth occupied by bright lines (call them interspaces, if you please). Then if the bright lines of oxygen were thrown down at random beside the solar spectrum, the chance of the center of any bright oxygen line falling opposite to a dark space or line would be one half, and the chance of the center of eighteen such lines so thrown down, all falling opposite bright interspaces, would be two to the power of eighteen, to one.

In addition to this, we must take into account the chances of the centers of the bright lines appearing to coincide with the centers of the bright interspaces where they do coincide, for in some instances the interspaces are double the breadth of the oxygen line, the oxygen line being on one side, and coinciding with one edge of the interspace; but this is accounted for by the fact that there are probably other bright lines in the solar spectrum besides oxygen lines, and two such bright lines happen in some instances to fall together. Then, also, it must be remembered that the light of the bright lines of the solar spectrum has suffered absorption in the solar atmosphere and in the earth's atmosphere, so that they may be modified by the superposition of absorption lines.

The observations of the chromosphere render it probable that the layer of the solar atmosphere, from which we receive the bright lines of the oxygen spectrum, lies below the chromosphere, and probably below, at all events, a portion of the reversing stratum which gives rise to the dark lines, so that it is possible to conceive that the oxygen lines of the solar spectrum might be modified as we observe them by the superposition of dark lines, and this appears in one or two instances to have been the case, but the character of the bright interspaces is very little changed. If, after examining the photographs, anybody has still any doubts as to the case made out by Dr. Draper, I think he will feel obliged to them if they will state their objections, and give him an opportunity of removing their doubts.

Mr. Christie said: Dr. Draper has been kind enough to give me an opportunity of examining his very beautiful photographs, and I wish to express the great admiration of the splendid results which he has obtained. I must confess that his photographs are far superior to anything of the kind I have seen. But that they prove the existence of oxygen in the sun is quite another question. I think that the probability spoken of by Mr. Ranyard is quite misleading. I dispute his facts. Such a method of estimating probabilities is very dangerous; you may prove anything by it. I am simply anxious to get at the truth, and am in the position of a skeptic, which is, I think, the true scientific attitude in such matters. We must take into account that former physicists have failed to identify any of the bright lines of oxygen with dark lines in the solar spectrum, and, therefore, we start with the fact that none of the oxygen lines fall opposite to dark lines.

If, instead of attempting to match bright lines of the oxygen spectrum with bright lines in the solar spectrum, Dr. Draper had commenced the other way, and had attempted to match bright lines in the solar spectrum with the oxygen lines, I think he would have had great difficulty in picking out the parts of the solar spectrum which were to be considered as bright lines. In more than one instance I find an oxygen line opposite a broader bright space in the solar spectrum which appears of identically the same brightness in its whole breadth. If the broader space consists of two or more bright lines, as has been suggested, we have two difficulties to contend with: in the first place, we have to show that there are other substances which would give lines corresponding to the unoccupied breadth, and in the second place, we have to show that these lines are undistinguishable in brightness from the oxygen lines.

Now, if we are to make use of probabilities, I would ask, what is the probability of such a pair of lines being together? At any rate, no other substance has at present been found which shows such adjacent lines. If we accept Dr. Draper's theory, that the solar spectrum is made up of a continuous spectrum with bright lines upon it, and that these are again modified by dark lines, we shall be landed in absolute uncertainty, for we shall not be able to ascertain whether any of the ordinary dark lines are merely interspaces between bright lines, or whether they are absorption lines.

Mr. Proctor said: There are one or two points I should like to mention. I do not think that Mr. Christie has taken sufficient account of the fact that all the bright oxygen lines fall entirely opposite to the bright interspaces, and that none of them even partially overlap dark lines. With regard to the general character of the solar spectrum, I would like to ask those who have more especially studied the subject, whether there seems to be any antecedent probability that we should have a continuous spectrum, as well as bright and dark lines, such as would be given by matter in the gaseous state? Perhaps some of you have considered the bearing of Mr. Croll's researches on this matter. He considers that the earth affords evidence that the solar system has been in existence for more than 20,000,000 of years, whereas, if the sun has been giving out energy as at present for 20,000,000 of years, we know that it cannot have derived it from shrinking from a mass of the size of the earth's orbit down to a mass of the size of the photosphere.

I am not inclined to agree with him in his explanation that it may have been derived from the impact of stars, but rather think that it points to the fact that the real mass of the sun lies very much within the photosphere, and that if there is any solid or liquid nucleus, it is only at a depth of many thousands of miles below the photosphere. If that is the case, I would ask whether it is antecedently probable that there should be any continuous background in the solar spectrum? If the photosphere is purely gaseous, we should only have bright lines interfered with and modified by absorption lines.

Dr. Gladstone said: When Dr. Draper's photographs came over a year or two ago I did not feel convinced, but certainly the evidence which Dr. Draper has brought forward since has greatly strengthened his case, so that I do not think there is now any possibility of doubting that the coincidences are real. I am not disposed to give up the idea that we may have a continuous spectrum underlying the dark lines, but we know that when we look at the edge of the sun there are bright lines corresponding to hydrogen and some other elements to be seen, but there are no oxygen lines. Now, I would suggest that this shows that the oxygen never gets up to the level of the chromosphere, so as to be seen at the limb of the sun, and probably that is just the reason why we see its lines as bright lines and not as dark lines, for it never gets up to a level where it is sufficiently cool to give dark lines. We can easily understand that, with all the iron and magnesium vapor rushing upward, all the oxygen in the higher levels may enter into combination and fall in a rain of oxides.

Dr. Huggins said that he had examined Dr. Draper's photographs, and was overwhelmed with a sense of the conscientious care which he had evidently bestowed upon the investigation. Dr. Draper had made out a *prima facie* case, which entitled him to demand a careful examination of the subject, but, for his own part, he should like to suspend his judgment until he had examined the coincidences for himself; personally, he should prefer to rely on his own eye rather than on the photographs, but he wished to state how thoroughly impressed he was with the cautious and careful experimental arrangements which Dr. Draper had adopted.

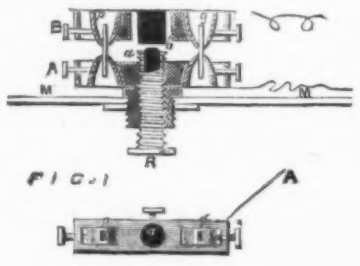
Mr. Ranyard said: I should like to remind Mr. Christie that only a few of the dark lines have been matched with the lines of known elements, and there may be a great many of the bright lines which will always remain unaccounted for, owing to the difference in the conditions of matter as examined in our laboratories and on the sun. With regard to the improbability of two adjacent lines being undistinguishable in brightness, it should be remembered that the brighter parts of Dr. Draper's photographs are over-exposed, and in such over-exposed parts two lines of very different brightness might be undistinguishable, although there may be considerable difference between them.

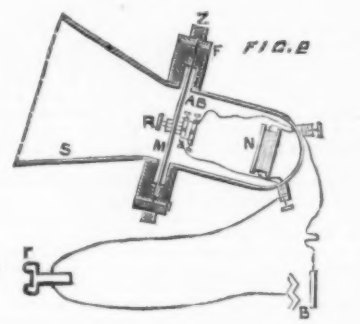
Mr. Christie said he was not prepared to admit the exactness of all the coincidences that had been referred to, and that with regard to the differences of brightness which might be perceived with the eye and could not be perceived in the photographs, he had examined these parts of the spectrum, and had failed to see any difference in brightness.

THE MICROPHONE TELEPHONE.

THE following diagrams and description of the universal telephone of Dr. Luedtge, which was patented before the microphone was invented, is given by the *Deutsche Industrie Zeitung*. We believe that the device as illustrated represents the latest improved form, which is now regarded by the inventor as a universal telephone adapted for all purposes. A Bell telephone is, however, employed as the receiver.

The essential part of the instrument is the connection between the two electric conducting bodies, *a* and *b*, Fig. 1





(preferably of iron, platinum, or carbon). One of the pieces, *b*, is level at the contact surface, but the other, *a*, is rounded. The electric current passes through this contact, and the variations in the electrical resistance at this point, while speaking, cause the vibrations of the membrane in the receiving telephone. A peculiarity of Luedtge's device is that both of the contact pieces are united to a support fastened to the middle of the membrane, M, so that both vibrate with the membrane. The contact piece, *a*, rests in a rectangular brass frame, A. The contact piece, *b*, is supported in a similar manner by the frame, B. The two frames, A and B, are connected to each other by means of strips of caoutchouc, *p* and *g*. Caoutchouc is a poor conductor of sound vibrations. The tone vibrations transmitted to the membrane, M, are received by the contact piece, *a*, unimpaired and with their entire power, but to affect the contact piece, *b*, they must pass the rubber strips, *p* and *g*. By this contrivance their intensity is materially decreased or modified, and there is a difference in the vibrations of *a* and *b*. The small screws serve to regulate the compression of the caoutchouc strips, *p* and *g*. Fig. 1 shows vertical and transverse sections. Fig. 2 is a transverse section of the complete apparatus. S is the tone receiver, M a wooden diaphragm, F the casing of the same, Z Z pivots for hanging the apparatus in bearings. A and B are the contact frames; R is a screw for partially regulating the contact by moving one of the contact pieces; *k* and *l*, screws for fastening the wires; B is the battery; T the receiving telephone; and N a resistance coil. To adjust the apparatus very carefully, it is turned on its horizontal axis. The susceptibility of the apparatus is so great that the small change on the pressure that B produces on A in turning the apparatus, is sufficient to regulate the contact.

ARE BIRDS DERIVED FROM DINOSAURS?

PROF. B. F. MUDGE, Manhattan, Kansas.

WE hear, repeatedly, that the dinosaurs are the ancestors of birds, or the stock from which the latter have been derived by evolution. A few points of resemblance, first noted many years ago, have been constantly repeated, without considering numerous other points of dissimilarity which a more thorough knowledge of new genera and species has afforded. The fact that the bones of the hind feet of a few species closely resemble those of birds, and some of the bones were hollow, gave rise to the hasty conclusion that other resemblances would be found, and that the bird was the outgrowth of the reptile. While a few foreign species have three toes, like the bird, some of the European and nearly all of the American, have four and five toes, and the structure and number of bones to the toe are closely reptilian. When there is a divergence from the reptilian type the feet approach the mammalian structure more than that of birds. This is seen in the numerous species and genera of the Sauropoda. In all cases, also, where there are but three toes, and those in structure are like the birds, the other bones of the foot and leg do not approach the type of the birds. When four toes are seen in the dinosaur, the fourth never turns backward like that of the bird. The most characteristic bone in the bird—the tarso-metatarsus—is, in the dinosaur, represented by the usual number characteristic of the reptiles, namely, five to eight bones instead of one; and in no case is there a tendency to consolidate. The tibia and fibula of birds are consolidated, while in the dinosaurs these bones are always separate.

It will be seen that if the legs of the dinosaur tended to a development toward the bird structure, this development is not harmonious, as it should have been; but in the few cases where the toes are bird-like, the other bones of the foot and leg show no such tendency.

Following the structure of the skeleton further, we find the pelvic bones of the bird always consolidated; those of the dinosaur never. Except in a few cases these bones are very different in shape. The termination of the caudal vertebra of the dinosaur is always small and does not tend toward the plowshare structure of the birds.

A still more marked feature is the want of approximation of the dinosaur to the bird, in the sternum or breast-bone. This, in the bird, is the bone, more than any other, which is mostly enlarged and singularly developed. Even in the ostrich and fossil Hesperornis, and other birds without wings, it is a large, massive bone. But in the thirty-five or more genera, embracing more than twice that number of species, of dinosaurs, only two have any trace of a sternum, even cartilaginous. In one European and one American species there is a small, slender, flat sternum, entirely unlike that seen in the bird, very reptilian in its structure. It has no shape that can be simulated to that of the bird. As a necessary result the clavicle (*furculum*), so marked in birds, is also wanting, though a rudimentary one is inferred in Apatosaurus.

The differences between the wing bones and those of the front feet of the dinosaur are as marked as in any other portion of the skeleton. If the one had been the outgrowth of the other, then we should have seen an early and more rapid change in the fore foot of the reptile, than in the hind foot, inasmuch as the wing is far different in shape from the foot. But when the dinosaur has but three toes, like a bird, in the hind foot (losing two from the typical reptile foot), the fore foot has four toes. When the dinosaur has four toes in the hind foot, there are five in the front foot, all clinging to the reptilian type, and showing no divergence in the shape or structure toward the two closely united fingers of the wing. If the bird were a descendant, by evolution, from the dinosaur, the change of a foot to a wing should have begun early, and the development should have been more marked and rapid than that of the hind foot. But no indications of such change is seen, or the slightest tendency to form a wing, in all the fifty or sixty species of dinosaurs that have been described.

The hollowness of the bones is less a marked feature of the dinosaurs than is usually supposed, and cannot be considered a marked characteristic; as more than half of the genera have no pneumatic cavities like birds, but bones of the solid or medullary structure of mammals. In Camarasaurus of Cope the hollow chambers assume a singular structure entirely unlike that of birds. The long bones are solid or medullary; but the vertebræ, which in birds are solid, have open re-entering cavities, which add lightness and strength, and may have been pneumatic. But the hollowness, such as it is, has no resemblance to that of the long bones of birds.

The articulations of the vertebræ, when not retaining the reptilian traits, are more like mammals than birds. The bird articulation, so peculiar and so persistent, sometimes called "saddle-shaped," is not found in any dinosaur. But in the fossil Ichthyornis (first discovered by the writer in Kansas), a bird in this respect of low type, the vertebræ do not approach any form peculiar to the dinosaurs, but are fish shaped, or bi-concave.

It will thus be seen that, while in a few features there may be some resemblances between dinosaurs and birds, just as there are between the former and mammals, the details of the structure of the skeletons show, as a whole, very widely different elements. The dinosaurs vary so much from each other that it is difficult to give a single trait that runs through the whole. But no single genus, or set of genera, have many features in common with the birds, or a single persistent, typical element of structure which is found in both.

The geological position of the dinosaurs, too, precludes the idea that they are the ancestors of the birds. They appear at the same time (in the Triassic), as the birds, instead of preceding them, and they continue to the Eocene; and the later specimens do not approximate any nearer to bird forms than the first.

If the birds were derived, by the process of evolution, from the dinosaurs, then the latter should have appeared first, and as geological time progressed, should, harmoniously, in every organ, assume a nearer and nearer approach to the bird type, and finally disappear in the flying biped. When it became a bird, it should have ceased to be a dinosaur, just as the child disappears in the man. The last one at the close of the Cretaceous, when the type became extinct, had no nearer approach to the bird than the earliest in the Triassic. Laosaurus, which, of all the twenty-seven American genera, approaches in the toes and pelvis nearest to birds, is found in the Wealden; and, in legs, fore feet, and absent sternum, has no approximation to a bird.

No dinosaur has ever shown a fore foot approximating in the slightest degree to a wing. The first bird was as distinctly a bird, with feathers and wings, as any now living. True, Archæopteryx had a tail of twenty vertebræ, but that is an appendage in common with the lowest reptile and the monkey, and does not ally it to the dinosaurs any more than to those animals. The fossil birds differed as strongly from each other as those now living. The Hesperornis and Ichthyornis lived and ran out together, the one without wings and with a common bird vertebra; the other with strong wings and a fish-like vertebra. Others lived with them closely allied to living species.

With so little to sustain the evolution of the bird from the dinosaur, can it be accepted as a geological fact?—*Kansas City Review.*